THE BRITISH SOCIETY FOR THE PROMOTION OF VEGETABLE RESEARCH

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# Sixth Annual Report

## 1955

(OCT. 1954 - SEPT. 1955)

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NATIONAL VEGETABLE RESEARCH STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1956

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## THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research,' with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Ministry of Agriculture, Fisheries and Food. At the outset the Society depends for its funds on grants from this Ministry, except that if any stations are established or work is conducted in Scotland, grants will be receivable also from the Scottish Agricultural Advisory Council. Both Agricultural Departments are advised by the Agricultural Research Council (A.R.C.) who have the scientific oversight of the work and staff.

# GOVERNING MEMBERS OF THE SOCIETY

**Appointed by the Minister of Agriculture, Fisheries and Food :**

Professor K. MATHER, D.Sc., F.R.S., Department of Genetics, The University, Edgbaston, Birmingham, 15.

Sir EDWARD SALISBURY, C.B.E., D.Sc., LL.D., F.R.S., F.L.S., V.M.H., Royal Botanic Gardens, Kew, Surrey. (Until 27/9/55)

H. V. TAYLOR, Esq., C.B.E., D.Sc., A.R.C.S., V.M.H. (Chairman), Preston Grange, Barnet Road, Potters Bar, Middlesex.

Professor P. T. THOMAS, B.Sc., Ph.D., Department of Agricultural Botany, The Institute of Rural Science, University College of Wales, Penglais, Aberystwyth.

Professor C. W. WARDLAW, Ph.D., D.Sc., F.R.S.E., Department of Cryptogamic Botany, The University, Manchester, 13. (From 28/9/55)

**Appointed by the Secretary of State for Scotland :**

R. L. SCARLETT, Esq., C.B.E., C.D.A., Sweethope, Musselburgh, Midlothian.

**Appointed by the Department of Scientific and Industrial Research :**

R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.

**Appointed by the University of London :**

Professor J. W. MUNRO, C.B.E., M.A., D.Sc., Frognall Cottage, Sunninghill, Berks.

**Appointed by the University of Reading :**

Professor R. H. STOUGHTON, D.Sc., A.R.C.S., V.M.H., Department of Horticulture, The University, Reading.

**Appointed by the University of Cambridge :**

J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Downing Street, Cambridge.

**Appointed by the University of Bristol :**

Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S., University of Bristol Research Station, Long Ashton, Bristol.

**Appointed by the University of Edinburgh :**

ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E., University Department of Botany, at Royal Botanic Garden, Edinburgh, 4.

**Appointed by the Royal Society :**

Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

**Appointed by the John Innes Horticultural Institution :**

K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

**Appointed by the National Farmers' Union :**

A. H. BOARDMAN, Esq., A.M.I.B.A.E., Lunts Farm, Paglesham, Rochford, Essex.

A. A. CLUCAS, Esq., Red Trees, Lathom, Ormskirk, Lancs.

G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.

J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.

W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

**Appointed by the National Farmers' Union of Scotland :**

DAVID LOWE, Esq., C.B.E., Elvingston, Gladsmuir, East Lothian.

**Appointed by the Horticultural Trades' Association :**

J. S. W. CRACKNELL, Esq., V.M.H., c/o Watkins and Simpson Ltd., 27 Drury Lane, London, W.C.2.

**Appointed by the Royal Horticultural Society :**

F. A. SECRETT, Esq., C.B.E., F.L.S., V.M.H., Hurst Farm, Milford, Godalming, Surrey. (Until 26/4/55)

R. E. THODAY, Esq., St. John's College Gardens, 18 Madingley Road, Cambridge. (From 4/5/55)

**Appointed by the National Allotments and Gardens Society :**

Professor J. CALDWELL, Ph.D., D.Sc., Hatherly Biological Laboratories, Prince of Wales Road, Exeter.

**Appointed by the Seed Trade Association of the United Kingdom :**

ARTHUR L. DEAL, Esq., c/o W. W. Johnson and Son Ltd., Boston, Lincs.

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**The Executive Committee**

Professor W. BROWN
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq. (From 9/6/55)
DAVID LOWE, Esq. (Chairman)
Professor K. MATHER
Professor J. W. MUNRO
F. A. SECRETT, Esq. (Until 26/4/55)
Professor R. H. STOUGHTON
W. F. SWIFT, Esq.
Professor T. WALLACE

**Staff and Research Sub-Committee**

Professor W. BROWN (Chairman)
A. A. CLUCAS, Esq.
A. L. DEAL, Esq.
DAVID LOWE, Esq.
Professor K. MATHER
Professor J. W. MUNRO
F. A. SECRETT, Esq. (Until 26/4/55)
Professor R. H. STOUGHTON
Dr. H. V. TAYLOR
Dr. R. G. TOMKINS
Professor T. WALLACE

*Co-opted :*

C. E. HUDSON, Esq., C.B.E., N.D.H., V.M.H., Ministry of Agriculture, Great Westminster House, Horseferry Road, London, S.W.1.

**Buildings Sub-Committee**

J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
DAVID LOWE, Esq.
Professor J. W. MUNRO
R. L. SCARLETT, Esq.
F. A. SECRETT, Esq. (Chairman) (Until 26/4/55)
Professor R. H. STOUGHTON
Dr. H. V. TAYLOR
Professor T. WALLACE

**Farm Management Sub-Committee**

A. H. BOARDMAN, Esq.
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq.
R. L. SCARLETT, Esq.
F. A. SECRETT, Esq. (Until 26/4/55)
W. F. SWIFT, Esq. (Chairman)

*Co-opted :*

E. R. HOARE, Esq., B.Sc. (Eng.), M.I.E.E., National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds.

**Varieties Inspection Sub-Committee**

A. A. CLUCAS, Esq.
J. S. W. CRACKNELL, Esq.
DAVID LOWE, Esq.
F. A. SECRETT, Esq. (Chairman) (Until 26/4/55)
W. F. SWIFT, Esq.

*Co-opted :*

C. D. R. DAWSON, Esq., Ph.D., A. L. Tozer Ltd., Pyports, Cobham, Surrey.

F. G. POTTER, Esq., Sutton and Sons Ltd., The Royal Seed Establishment, Reading, Berks.

# STAFF

**Director :**

JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.), F.L.S.

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**Plant Breeding :** J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.
H. HOLLAND, B.Sc. (Wales).
A. G. JOHNSON, B.Sc. (Lond.), Ph.D. (Wales).
L. E. WATTS, B.Sc. (Wales).
G. J. FAULKNER.
G. J. FROST, B.Sc. (Dunelm). (Appointed 1/1/55)
E. M. WATSON, N.D.A., C.D.A. (Glas.). (Resigned 30/9/55)

*Assistants :* Miss C. H. BEARDALL, Dip. Hort. (Nott.).
D. D. CLARKE. (Returned from National Service 5/9/55)
Miss P. A. DYMOND. (Appointed 15/8/55)
Miss C. F. GANDERTON. (Resigned 13/11/54)
Miss K. HIGHMAN. (Resigned 28/12/54)
Miss W. HORN.
Miss J. M. H. INSLEY.
I. MITCHELL. (Appointed 15/11/54)
Miss P. M. RUSSELL. (Appointed 1/1/55)

**Chemistry :** F. HAWORTH, B.Sc., Ph.D. (Liverpool), Dip. Ag. Sci. (Cantab.), A.R.I.C.
S. P. SPRAGG, B.Sc., Ph.D. (Bristol). (Appointed 18/4/55)
E. E. H. PITT.

*Assistants :* P. B. BANHAM. (Appointed 8/8/55)
Miss M. BENNETT. (Appointed 1/4/55)
Miss A. BURGESS.
Miss J. WAGHORN.

**Irrigation :** E. J. WINTER, M.C., M.Sc. (Bristol).
P. J. SALTER, M.Sc. Hort. (Nott.).
G. STANHILL, B.Sc. (Reading). (Appointed 1/10/55)

*Assistants :* J. PARKER.
Miss J. I. E. RUBIO.
Miss J. SMITH.

**Entomology :** D. W. WRIGHT, M.A. (Cantab.).
J. A. DUNN, M.Sc. (Dunelm).
W. R. HOWELLS, B.Sc., Ph.D. (Wales). (Appointed 1/3/55)
G. A. WHEATLEY, B.Sc. (Dunelm).
Miss D. D. BOWE, B.Sc. (Dunelm).
J. S. BUXTON, B.Sc. Hort. (Nott.). (Appointed 1/12/54)
J. A. HARDMAN, B.Sc. Hort. (Nott.).

*Assistants :* H. I. SMITH.
Miss E. A. DEARDEN. (Resigned 9/8/55)
Miss J. MARCH. (Appointed 28/2/55)
Miss C. R. MARTIN. (Appointed 19/9/55)
Miss A. SARGENT.

**Pathology :** W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.
A. G. CHANNON, B.Sc. (Aberdeen).
Miss D. E. FISHER, B.Sc. (Lond.), M.Sc. Hort. (Nott.), A.R.C.S. (Working under A.R.C. grant)
J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
Miss J. S. HOWELL, B.Sc. (Birm.).
J. M. WAY, B.Sc. (Lond.).

*Assistants :* Miss J. CARPENTER.
Miss P. A. DADLEY. (Appointed 31/5/55)
Miss M. P. INSALL. (Appointed 19/9/55)
Miss J. THORPE. (Resigned 31/7/55)
Miss A. P. WARD, N.D.D.H. (Studley). (Working under A.R.C. grant)

**Weed Ecology :** H. A. ROBERTS, B.Sc. (Manc.).
J. K. A. BLEASDALE, B.Sc., Ph.D. (Manc.). (Appointed 1/1/55)
Miss M. E. SMART, B.Sc. (Lond.).

*Assistants :* Miss U. W. LAURENCE. (Appointed 2/8/55)
Miss C. M. ROWE.

**Vegetable Washing :** M. J. W. WEBB, B.Sc. Hort. (Nott.).

**Statistics :** J. A. NELDER, M.A. (Cantab.).
D. COOKE, B.A. (Oxon.).

*Assistants :* Miss J. FARNSWORTH. (Resigned 30/10/54)
Miss A. MEADUS. (Appointed 28/10/54)
Miss H. E. RUSSELL.

**Farm :** *Manager :* T. J. NORWOOD.

**Administration :** *Secretary :* J. C. WILKINS, LL.B. (Lond.), F.C.I.S.
*Accounts Assistant :* J. H. L. BRIDGEWATER. (Resigned 31/3/55)
D. A. BARTLETT. (Appointed 1/5/55)
*Administrative Assistant :* L. C. FITZGERALD. (Appointed 12/9/55)
*Librarian :* Miss B. M. BAGGS, M.Sc. (Liverpool). (Appointed 1/10/55)
*Director's Secretary :* Miss E. B. FORRESTER.
*Clerical Assistants :* Miss J. M. B. EDGERTON. (Appointed 16/8/55)
Miss J. M. LAMB.
Miss S. B. TOOKEY.
Miss M. A. WARR.

# REPORT OF THE DIRECTOR

## DEVELOPMENT

Further progress with building development was made during the year. The position now is that we have (in addition to the original buildings for livestock), farm stores, a machinery and implement shed, carpenter's and mechanic's workshops, and a shed for grading, washing, packing and general purposes, a building for threshing and storage of vegetable seeds, glasshouses, a soil sterilising and potting shed, boiler house and fuel store, a farm manager's house, nine cottages, drainage and sewage disposal works, electric power, a domestic water supply and irrigation system fed from our own borehole, a canteen, temporary laboratories, offices and library, and service roads to all the buildings and through the farm.

Apart from some of the temporary wooden laboratories and offices, which were erected by Station labour, the above development scheme has been in progress since November 1951. It now remains for the main block of laboratories and offices, together with library and lecture room, to be erected. Plans, specifications and estimates of costs for this building have been prepared and were approved in principle by the Agricultural Research Council, the Ministry of Agriculture, Fisheries and Food, and by the Treasury in October 1955. Tenders are to be invited and it is hoped that building work will be begun during the spring of 1956. The stage has thus been reached when the end of the main building development scheme is almost within sight.

## STAFF

Further additions to the staff were made during the year although a few research posts remained unfilled. Recruitment of skilled farm workers was made easier by the provision of cottages, but not to a marked extent because some of these cottages were taken up by workers already in our employment.

### Appointments

Dr. J. K. A. Bleasdale was appointed on 3rd January 1955 as a Scientific Officer in the Weed Ecology Section. Dr. Bleasdale had previously been working at Manchester University where he studied the effects of atmospheric pollution on plant growth.

Dr. W. R. Howells was appointed as a Scientific Officer in the Entomology Section on 1st March 1955. His post-graduate research on soil populations of insects and related soil factors was carried out at the University College of Wales, Aberystwyth.

Dr. S. P. Spragg, who came from the University of Bristol where he gained post-graduate experience in research studies on the nitrogen metabolism of maturing seeds, was appointed on 18th April 1955 as a Scientific Officer in the Chemistry Section.

Mr. G. Stanhill was appointed as a Scientific Officer in the Irrigation Section on 1st October 1955. He had been carrying out post-graduate research in that Section for two years under a scholarship from the Ministry.

Mr. J. S. Buxton was appointed to the Entomology Section as an Assistant Experimental Officer on 1st December 1954.

Mr. G. J. Frost was appointed on 3rd January 1955 as an Assistant Experimental Officer in the Plant Breeding Section.

The following eleven Scientific Assistants were appointed during the year, five of whom replaced those who had resigned :—

Miss A. Meadus, Statistics
Mr. I. Mitchell, Plant Breeding
Miss P. Russell, Plant Breeding
Miss J. March, Entomology
Miss M. A. Bennett, Chemistry
Miss P. A. Dadley, Plant Pathology
Mr. P. B. Banham, Chemistry
Miss P. A. Dymond, Plant Breeding
Miss U. W. Laurence, Weed Ecology
Miss M. P. Insall, Plant Pathology
Miss C. R. Martin, Entomology

Seven University students were employed to assist in research during the summer.

Mr. D. A. Bartlett was appointed as Accounts Assistant on 1st May 1955 in succession to Mr. J. H. L. Bridgewater.

Mr. L. C. Fitzgerald was appointed on 12th September 1955 as Administrative Assistant.

Miss B. M. Baggs was appointed as Librarian on 1st October 1955, having relinquished a similar post with the Grassland Research Institute when it transferred from Stratford-upon-Avon to Hurley.

Miss J. M. B. Edgerton was appointed as Telephone-Operator/Typist on 16th August 1955.

**National Service**

Mr. D. D. Clarke resumed his duties as a Scientific Assistant in the Plant Breeding Section on 5th September 1955, having completed his National Service training.

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Mr. M. J. W. Webb who was seconded in October 1952 to the Ditton Laboratory of the Department of Scientific and Industrial Research at East Malling, Kent, in order to assist in investigations on the deterioration of vegetables subsequent to washing, transferred to Wellesbourne in July 1955 when facilities for this work became available.

**Resignations**

Mr. E. M. Watson resigned on 30th September 1955 to take up a post in Kenya as a Government Agricultural Officer (Experiments).

Five Scientific Assistants resigned during the year ; Miss J. Farnsworth and Miss J. Thorpe left to be married, and Miss K. Highman, Miss C. F. Ganderton and Miss E. A. Dearden left to take up posts elsewhere.

Mr. J. H. L. Bridgewater, one of the group of five who occupied the first wooden hut on the Station, resigned on 31st March 1955 to take up another post. He was a popular colleague and did much for the social welfare of the Station.

Mr. F. Rix, Clerk of Works, resigned on 13th August 1955, when the building contract was almost completed.

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Various conferences were attended by members of the research staff during the year. In October 1954, Mr. D. W. Wright attended the National Agricultural Advisory Services (N.A.A.S.) Conference of Entomologists and the A.R.C. Technical Conference on Research on Aphids, in London. Mr. H. A. Roberts read a paper on 'Contact pre-emergence treatments for vegetable crops' at the British Weed Control Conference held in Harrogate during November 1954. In December 1954, Dr. J. C. Haigh attended the Annual General Meeting of the National Farmers' Union, Essex Seeds Branch, when he spoke on plant breeding and seed production work at the N.V.R.S. He also read a paper on 'Vegetable Breeding' at a conference on plant breeding, organised by the Northern Branch of the Horticultural Education Association and held in Darlington in March 1955.

Dr. W. G. Keyworth and Dr. J. A. Tomlinson attended the N.F.U. Watercress Conference held in Andover in March 1955, when Dr. Tomlinson spoke on crook root and virus diseases of watercress. During the same month, Dr. Haigh, Mr. J. A. Nelder, Dr. A. G. Johnson and Mr. L. E. Watts were present at the Royal Society's Symposium on Hybrid Vigour, held in London. Miss D. D. Bowe attended a seven-day course on soil zoology in April at the University of Nottingham School of Agriculture, Sutton Bonington. Mr. Wright was present at the A.R.C. Technical Conference on Insecticide and Fungicide Research held in London in April. The Director, Mr. Nelder and Dr. Haigh attended the Genetical Society meeting which

was held during July at Aberystwyth. In July, Miss D. E. Fisher read a paper on 'Didymella disease of tomatoes' at the General Meeting of the Association of Applied Biologists which was held in Oxford ; and at the same meeting Mr. G. A. Wheatley read a paper on 'Factors governing the toxicity of DDT dust deposits to the pea aphid'. Mr. E. J. Winter, Mr. P. J. Salter and Mr. G. Stanhill took part in a seminar at Nottingham University, in July, when soil moisture measurement was discussed. Mr. Winter and Mr. Salter also attended the H.E.A. Conference held at Reading University in September. The 14th International Horticultural Congress, held in Scheveningen, Holland, during August-September was attended by the Director, Dr. Keyworth, Dr. Haigh and Mr. Winter. Dr. Haigh spent two days at the Horticultural Research Institute, Wageningen, Holland, discussing vegetable breeding problems, and spoke on vegetable breeding in Great Britain at a Conference on Vegetable Varieties held in Wageningen.

During the summer of 1955, Mr. Watts was enabled again to visit the lettuce-growing areas of France, Germany and Holland, by means of a grant kindly provided by the A.R.C. As a result of reciprocal visits of this nature and of observations made in these countries, an advanced type-written copy of the proposed index to the international paper on lettuce synonymy was issued to those directly concerned with this work, at the Conference on Vegetable Varieties in Wageningen.

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The staff had a Christmas lunch on 17th December 1954, when 60 people had an excellent meal in the new canteen. That evening the Station choir, under the direction of Mr. Nelder, gave a programme of Christmas carols and other music which was greatly appreciated by staff and friends. The fourth Christmas-New Year party was held in the canteen on 7th January 1955, when the staff and their friends, making a total of 99, had a most enjoyable evening. Thanks are due to the Sports and Social Committee who organised the party, to the Chemistry Section who arranged the catering, and to many other members of the staff for the able part they played in the evening's entertainment.

The Sports and Social Committee consisted of Miss Bowe, Miss Fisher, Miss Forrester, Mr. Nelder (Chairman), Dr. Haigh (Treasurer) and Mr. Cooke (Secretary). Sub-committees again dealt with cricket, hockey, netball and tennis, and a new sub-committee was formed to organise gramophone concerts. The cricketers won six matches, lost ten and drew two with local clubs. The hockey players won one and lost three matches. Several fixtures had to be cancelled owing to bad weather. The highlight of the Station's sporting season was the occasion when, at the kind invitation of Long Ashton Research Station, matches were played between teams from the two Stations at the Bristol University sports ground on 9th July. Long Ashton won the cricket match by the narrow margin of ten runs, while the N.V.R.S. won the tennis by the narrow margin of one match. We are most grateful to Long Ashton staff for the enjoyable day's sport and for their kind hospitality to the teams and supporters from Wellesbourne. We hope that in the near future the N.V.R.S. will be in a position to invite Long Ashton to have return matches. Thanks are due to the Trustees of the Clucas Trust Fund for a donation to assist the staff in its sports and social activities.

## RESEARCH

On 23rd and 24th May 1955, an A.R.C. Visiting Group inspected the work in progress at the Station and considered the proposed general programme for the five-year period 1955-60. The group consisted of Professor P. H. Gregory, Professor E. J. Maskell (Chairman), Dr. I. Thomas, Professor P. T. Thomas, Mr. D. Trehane, and Professor R. L. Wain, and was accompanied by members of the Council's staff, Sir William Slater, Secretary to the Council, Mr. W. G. Alexander, Dr. E. E. Cheesman and Mr. G. G. Samuel. The group agreed the five-year programme with the Director, and subsequently produced a report of the visit which was adopted and agreed by the A.R.C.

**Plant Breeding**

The $F_2$ generations from crosses between summer lettuce varieties which showed little attack by mosaic, and between these varieties and a wild species, have been produced. A small proportion of $F_2$ plants was free from mosaic and these plants were used for further breeding and selection. A severe attack of root aphid on a collection of lettuce varieties showed that the following four varieties suffered least and produced a marketable crop—White Favourite (Barr), two American varieties Midas and Salad Bowl, and Reine de Glace (Vilmorin). 102 frame varieties and 84 winter lettuce varieties were examined for synonyms.

Breeding work with red beet has been in progress with the object of combining uniformity, freedom from bolting, good root colour and absence of rings in the roots, these characteristics having been found separately in different varieties. Crosses have been made also with the intention of transferring the single-seeded fruit character from an American variety into a good British variety.

Breeding material has been selected out of the best varieties of spring cabbage in the trials at Wellesbourne and will be used in an attempt to produce an improved dual purpose variety, i.e., suitable both as greens and hearted cabbage.

Breeding work has been started with the intention of producing asparagus seed which will give all male plants (males are preferred to female plants) and which may also show hybrid vigour.

Male sterility found in Cambridge varieties of onions, and present in material obtained from America, is being used in the production of hybrid varieties which are expected to show improvement in uniformity and yield. Blow-flies are being used as pollinators.

First and second inbred generations of Cambridge varieties of Brussels sprouts have been produced as part of the programme of making hybrid varieties, i.e., hybrids between inbred lines, which it is hoped will show improvements in uniformity, yield and other characteristics as compared with ordinary varieties. As expected, there was some depression in the vigour of the inbreds although it was not great, uniformity within inbred lines was improved, and inbred lines differed distinctly in important characteristics thus permitting selection to be carried out on a clear cut basis. Vegetative propagation and methods of controlling flowering are being used in this breeding work. Bees are also being used in our controlled breeding work with brassicas.

Supplies of nucleus stock seed of those Cambridge varieties which are on the market were produced, as usual, for further multiplication by the N.I.A.B. Stock seed was distributed by the N.I.A.B. for the first time to recognised seed growers for the production of commercial seed under the new scheme as described in the Annual Report for 1952.

**Chemistry**

The work of this relatively new section so far has been, of necessity, more in the nature of agronomy than chemistry. The long-term field experiments have been in progress for two years, with a wet summer in 1954 and a dry one in 1955, and some interesting differences are already apparent in the results. In 1954, peas, Brussels sprouts and spring cabbage responded better to deep cultivation than to shallow cultivations but the reverse held for leeks. Brussels sprouts and leeks responded markedly to phosphate together with potash whereas peas did not. F.Y.M. had a striking effect in both years on early potatoes, spring and summer cabbage, leeks and carrots. It was also noteworthy that a single early application of inorganic nitrogen to these four crops gave an effect as good as, and sometimes better than the same total amount of inorganic nitrogen given in four separate applications.

The analysis of soil samples taken from plots in the above long-term experiments in 1953 has been completed and the results show that the soil was remarkably uniform. The detailed soil survey of the Station started in 1953 has also been completed. Analytical work, using chromatographic techniques, on plant material from field experiments was begun during the autumn of 1955 when a laboratory was equipped for this purpose.

**Irrigation**

Irrigation experiments with different vegetables were carried out during 1955. Early cauliflower grown under three soil moisture regimes, and protected from rain, showed no response to the irrigation treatments. This result may have been influenced by the unusually deep soil allowing root development at greater depth and hence the better tapping of natural water supplies. Autumn cauliflowers, again protected from rain, responded equally well to a wet regime as to a medium regime but the dry regime greatly delayed maturity and resulted in a poor yield.

Wet and dry treatments were applied to turnips at different stages of development and it appeared that these treatments had the greatest effect during the three weeks prior to harvesting, thus indicating that turnips should have a plentiful supply of water during this period.

With peas, runner beans, broad beans and carrots, a dry regime gave poorer yields than either wet or medium regimes and there was some indication that yields from the medium were slightly better than those from the wet regime. With red beet and marrows, however, irrigation did not improve the yield. Irrigation increased leaf production in all these crops except red beet.

Studies were continued on water loss from plants and soils, under field conditions. Work was also done on the development of a combined rain-gauge and evaporimeter which might be used by growers to determine how much irrigation water should be applied. As a sideline, but having an important objective, a system was developed successfully for cooling small, insect-proofed compartments in glasshouses during hot weather.

**Entomology**

An experiment showed that a satisfactory control of cabbage root fly in a cabbage seed-bed was obtained by either of the following treatments—spraying the seedlings with aldrin, dieldrin or lindane, or dressing the seed with lindane. The carry-over effect was not enough, however, to give adequate control in the field and additional treatment of the transplanted crop was necessary.

Further experiments on root dip treatments for cabbage plants confirmed that dieldrin at a concentration of 0.06 per cent, either in suspension or as an emulsion, gave almost complete control of cabbage root fly. Aldrin was less satisfactory, and the concentration of lindane required for satisfactory control was liable to be phytotoxic. As a rule, drench treatments give better control than dipping and the latter may cause a check in growth when conditions for transplanting are not satisfactory.

Laboratory studies have shown that more than thirty species of beetles and two species of mites prey on one or more of the immature stages of the cabbage root fly. Some of these species were found to be voracious feeders and this, together with studies of insect populations in the soil, indicated that these predatory insects could play an important part in reducing the natural populations of cabbage root fly. This was supported by evidence from a field experiment where low rates of insecticides were broadcast two weeks prior to transplanting cabbages. The insecticides reduced the population of beetles, an effect which lasted for several months, and in consequence the cabbages suffered more damage from cabbage root fly in the treated plots than in the untreated plots.

Field experiments again showed that seed dressings of either dieldrin or gamma B.H.C. gave a good control of the first generation of carrot fly, and that subsequent sprays with dieldrin were necessary to reduce the attack by the second generation of the fly on maincrop and late carrots. Dieldrin caused no tainting of the carrots but gamma BHC used as a seed dressing was apt to produce taint.

Studies have been continued on the biology and habits of the carrot fly and its larvae which attack parsnips, and field experiments were begun in an attempt to find a good method of controlling this pest on parsnips.

Work was started on the biology and control of the lettuce root aphid and a heavy infestation of this pest during the summer of 1955 allowed good progress to be made. Different insecticides were used at various strengths as seed treatments and as seedling

treatments. A seed dressing of 50 per cent endrin gave a good degree of control. The discovery of lettuce varieties resistant to the aphid, mentioned earlier under plant breeding, gave another important line of approach, however, to the solution of the problem.

Investigations were continued on the cumulative effect of the temperatures occurring under different soil conditions on the development of pea moth larvae from different sources. These studies may make it possible to predict when pea moths will emerge in a pea crop and hence to obtain control of the pest by spraying with DDT emulsion at the proper time.

**Pathology**

Experiments in miniature watercress beds showed that the loss of carbon dioxide or of iron compounds from the water as it flowed down the beds was not connected with crook root disease and the decrease in plant vigour. Another experiment suggested that variation in the degree of infection by crook root was connected with the concentration of zoospores in the water. Following the discovery that calcium bicarbonate had a suppressing effect on crook root with increasing concentrations up to 500 p.p.m., a survey showed that more than 100 beds had a total bicarbonate content of 300-400 p.p.m., and only one bed had 550 p.p.m. ; this bed was free from the disease. Investigations on the control of crook root, and on watercress virus are being continued.

The seed-borne bacterium shown to be the cause of the silvering disease of seed crops of red beet, variety Cheltenham Green Top, has been found to be similar to, but not identical with, the bacterium causing tomato canker. Seed treatment with the antibiotic streptomycin has almost completely controlled seed-borne infection up to the steckling stage, but the effect on the mature crop has yet to be observed.

Partial success has been achieved by heat treatment of cuttings for the control of rust in field crops of mint, but it appears that the crop is readily re-infected after the first crop is cut. Species and varieties of mint are being tested for resistance to rust and a few have shown some resistance.

The warm dry summer of 1955 provided adverse conditions for the *Didymella* stem rot disease in outdoor tomatoes and consequently research on this subject was hindered. It was found that tomato seed can remain infected by the fungus for three years. Elimination of seed infection by hot water or dry heat treatment seems unlikely to be effective since the thermal death point of the fungus is generally greater than that of the seed.

It was shown that carrot fly damage to parsnips was not always a necessary precursor to an attack of parsnip canker. An equally heavy attack of canker occurred on uninfested roots, where carrot fly had been controlled by frequent heavy dressings of the insecticide dieldrin, as on roots which were heavily mined by the larvae of the fly.

Experiments on the comparative effectiveness of three fungicides, thiram, captan and TCNB, applied at various concentrations on winter lettuce for the control of the common diseases, mainly *Botrytis*, indicated that thiram at 0.33 per cent was the most effective. With the variety May Queen, grown under double-span Dutch lights, the spray was applied five times at 21-day intervals from January to March. Seedlings of the variety Imperial were given the same spray treatment while wintering under single-span Dutch lights, and were transplanted into the field early in April.

Work was continued on rhubarb virus diseases and some results suggest that one of the viruses may be related to cabbage ringspot virus.

**Weed Investigations**

Work was continued on the study of annual weeds as affected by different manurial and cultural treatments used in a rotation of different vegetable crops grown on what had been corn land. Studies were also continued on the behaviour and life cycle of important annual weeds of vegetable crops. Investigations were begun on the effect

of various methods of preparation of seed-beds on the emergence of annual weed seedlings. Studies were also started on the competition between weeds and vegetable crops. The initial results have confirmed the findings of practical experience in that it is best to control weeds during the early stages of crop growth and that intensive cropping must be accompanied by intensive weed control.

Further trials with miscible oil formulations of pentachlorophenol for weed control with onions, lettuce and red beet showed that this herbicide, when used correctly, gave a satisfactory performance. The ammonium and triethanolamine salts of both dinoseb and its isopropyl homologue were compared for their effectiveness as post-emergence herbicides for garden peas. The triethanolamine salts gave good weed control, slightly less than the ammonium salts, but they did no damage or only slight damage to the crop, whereas the ammonium salts damaged it. Four phenoxybutyric acid compounds were tested in the field against a range of vegetables and of annual weeds. Further trials will be made but the results so far indicate that one of the compounds MCPB is promising for use with peas and celery. Another year's work has confirmed that CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) is a very satisfactory herbicide for use against annual weeds in established asparagus beds. It has also given promising results as a pre-emergence treatment for asparagus seed-beds. Work is in progress with other compounds which may prove suitable for weed control in vegetables.

**Vegetable Washing**

The joint investigations on methods of commercial washing of vegetables and their effects on the keeping qualities of the washed products, carried out at the Ditton Laboratory of the D.S.I.R., were terminated when the member of our staff transferred to Wellesbourne in 1955. The D.S.I.R. is producing a report on the results of these studies on a wide range of vegetables. Observations were also made on the effects of packaging washed and unwashed vegetables. Well-trimmed, small Brussels sprouts, washed and unwashed, were packed in 1 lb. lots in transparent, perforated, polyethylene bags, and kept at different temperatures ranging from 33°F. to 60°F. Washing removed loose leaves, and the washed sprouts remained turgid for a longer time than the unwashed. Condensation of moisture was more severe inside the bags of washed sprouts and took longer to clear than in the bags of unwashed sprouts. The unwashed sprouts tended to wilt more rapidly and the bags became loose fitting ; also the loose leaves became yellow making the sprouts look less attractive than the uniform but paler green, washed sprouts. After three days at 60°F. both washed and unwashed sprouts became so yellow as to be unsaleable. At lower temperatures the rate of yellowing decreased and was slower with washed than unwashed sprouts ; sprouts kept at 33°F. for 14 days were still saleable but the rate of deterioration on removal to a higher temperature was more rapid than with freshly packaged material. Rotting was not a problem as it did not occur until after the sprouts had become unsaleable for other reasons.

**Statistics**

Advice and assistance have been given again to the research staff on the design of experiments, sampling technique and analysis of experimental results. This service has been given also, as usual, to the N.A.A.S. Experimental Horticulture Stations and to other bodies.

Investigations have been continued on methods of improving the efficiency and accuracy of field experiments with vegetables. Further work was carried out also on the genetics of continuous variation in French beans and on statistical problems connected with the subject.

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The Director has continued to act as Chairman of the Vegetable Working Party which co-ordinates the experimental work with vegetables on the N.A.A.S. Experimental Horticulture Stations, and he has served again on the Advisory Committees of

these Stations. The close relationships and co-operation between these Stations and the N.V.R.S. continued and we are grateful to them for again having carried out field experiments with vegetables in extension of those done at Wellesbourne by the various research sections.

We are also appreciative of the close relationship and collaboration between the N.I.A.B., Cambridge, and ourselves, in seed maintenance and multiplication work, and in the trials of varieties. The Director again served on the Vegetable Trials Advisory Committee of the N.I.A.B.

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## FARM

Once again the outstanding feature of the farming year 1954-55 was the weather. The winter, spring and early summer were very wet and cold while the late summer and autumn were dry and warm. In consequence, work was impeded in the early part of the year ; corn was not sown until after mid-March, seed-beds for vegetables were difficult to prepare and plant growth was slow. With the change in weather there was an excellent response in growth but, as the warm dry weather became a drought, so the root crops and pastures, with the exception of lucerne, suffered. On the other hand, weeds were easily controlled by cultural means, and haymaking and harvesting were carried out under excellent conditions and without interruption.

At Wellesbourne, silage and hay, about 100 tons of each, were made and stored by the beginning of July. Good crops of corn were obtained but the yield of potatoes was poor. Early summer vegetables suffered little from any of the usual pests but steps had to be taken to control aphids in August when they had become very abundant. During the prolonged drought the irrigation system proved to be invaluable ; it saved certain crops and made it possible to transplant and establish winter brassicas.

During the year, our cattle passed the necessary tests and became attested. 80 bullocks were wintered in the yards and were fed entirely on products of the farm. 37 were sold, fat, between December 1954 and May 1955, two of them being prize-winners at the Christmas Fatstock Shows and Sales at Warwick and at Stratford-upon-Avon. The remaining 43, and an additional 15 yearlings purchased at the Spring Sales, were summer grazed on the leys. Our pig herd has been developing steadily and it passed the attestation tests, and was registered as a vaccinated herd. The four foundation sows and four home-bred gilts farrowed in January and reared 87 pigs. The above eight sows and three more home-bred gilts farrowed in July and reared 99 pigs. Three young breeding sows were also transferred to the sub-station at Paglesham, and two young boars were sold for breeding. All the young pigs, apart from those selected for breeding, were fed and graded for bacon, and excellent grades were obtained. Three porkers and a pen of three cutters won second and third prizes, respectively, at the Warwick Christmas Fatstock Show and Sale. About 700 tons of dung was produced for use in vegetable production.

Some additional items of equipment were bought during the year and pig-farrowing huts were made by Station labour. Fuel pumps and tanks were installed, and part of the farm yard was concreted, the remainder being covered with hard-core and gravel. The piped water supply from our borehole was extended to the farm buildings, and to Cottage Field when the Dutch light frames were transferred there from Wellesbourne Gravel Pits.

As weather permitted during winter, quickthorn and beech were planted to form new hedges in place of those grubbed up a few years ago and to fill gaps in other hedges. Some young specimen trees were also planted and it is intended to make further plantings in the coming season.

At the sub-station at Paglesham, the weather made it necessary for most of the cereals to be spring sown. Despite the adverse spring weather and the almost unbroken period of hot, dry weather from mid-June to early September, the cereals gave quite good yields. Spring beans failed through the drought and had to be replaced

by a crop of peas. Potatoes grew well and, like the pasture, benefited from a few thunderstorms. A sharp attack of blight stopped growth of the potatoes at the end of August but, considering the season, satisfactory yields were produced. Our vegetable seed crops gave good yields of seeds which were harvested under excellent conditions. The yield of seed from two of the brassica crops was reduced, however, because the plants had to be transferred to another part of the farm in order to avoid cross-pollination by a seed crop of marrow-stem kale grown by a neighbouring farmer. Through friendly co-operation, arrangements have been made which should make this unlikely to happen again.

Thirty cattle were wintered in the yards and summer-grazed on the ley, O.S.48, until they were sold, fat. Three Essex sows produced their second litters and reared 27 pigs. These three sows were replaced by three Large White gilts from the Wellesbourne herd. The litter from one gilt died but the other two gilts reared 16 pigs. The livestock produced a good supply of dung for use in the production of vegetable seed crops. Additional implements were purchased during the year so that the amount of farm work done on a contract basis was further reduced. The roofs of three sheds were re-thatched.

## Visitors

The number of visitors to the Station during 1954-55 was 466. It gave us special pleasure to have a visit from Earl St. Aldwyn, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, on 8th September. It is also worthy of mention that the Station had its first visitors from the U.S.S.R., consisting of a party of senior politicians and scientists, including the Deputy Minister of Agriculture.

The following visitors came from overseas, many of them coming before or after attending the 14th International Horticultural Congress held in Holland in August-September :—

| | |
|---|---|
| *Australia :* | Mr. J. W. Holmes, C.S.I.R.O., Adelaide.<br>Mr. N. O. McLeod, G. Edgell & Sons Ltd., Bathurst, N.S.W.<br>Mr. W. A. T. Summerville, Department of Agriculture, Brisbane.<br>Mr. R. O. Slatyer, C.S.I.R.O., Canberra.<br>Mr. D. V. Walters, N.S.W. Department of Agriculture, Griffith. |
| *Austria :* | Dr. O. Nölz, Schonbrunn Horticulture School.<br>Herr F. Weber, Schonbrunn Horticulture School. |
| *Canada :* | Mr. C. J. Bishop, Experimental Farm, Kentville, Nova Scotia.<br>Mr. R. E. Fitzpatrick, University of British Columbia, Vancouver.<br>Dr. C. Walkof, Experimental Station, Morden, Manitoba. |
| *Denmark :* | Dr. Blangstrup Jørgensen, Statens Forsøgsstation, Esbjerg. |
| *Egypt :* | Dr. A. M. Ali, Ministry of Agriculture, Dokki. |
| *Holland :* | Dr. H. J. DeFluiter, Dr. J. G. Ten Houten, Dr. T. H. Thung, Ir. J. H. Van Emden — Institute of Phytopathological Research, Wageningen.<br>Mr. G. L. Koert, Mr. C. J. Legerstee, Mr. C. E. Van Loon, Mr. J. A. Van Nieuwenhuyzen — Members of the Dutch Onion Federation.<br>Mr. J. Van den Ende, Government Experimental Station for Horticulture, Naaldwijk.<br>Mr. P. Riepma, Central Institute of Agricultural Research, Duivendaal 10.<br>Mr. C. M. Rodenburg, Wageningen. |
| *Kenya :* | Dr. R. H. LePelley, Department of Agriculture, Nairobi. |
| *Malaya :* | Dr. E. W. Bolle-Jones, Rubber Research Institute, Kuala Lumpur. |
| *New Zealand :* | Mr. J. R. Corrigan, Hawera.<br>Mr. J. A. Hunter, D.S.I.R., Auckland. |
| *Sweden :* | Dr. G. Aberg, Royal Agricultural College, Uppsala. |
| *S. Africa :* | Dr. H. L. Pearce, Central Tobacco Research Station, Rustenburg. |
| *S. Rhodesia :* | Mr. C. B. Payne, Rhodes Inyanga Orchards. |
| *Tanganyika :* | Mr. J. F. Osborne, Sisal Research Station, Mlingano. |

*Tasmania :* Mr. E. C. McKay, Cambridge.

*Uganda :* Dr. G. M. Wickens, Namulonge.

*U.S.A. :* Dr. J. R. Shay, Purdue University, Lafayette, Indiana.
Professor J. C. Walker, University of Wisconsin, Madison.

*U.S.S.R. :* Mr. A. V. Alpatiev, Mr. I. F. Budanov, Mr. G. Y. Matkovsky, Mr. M. E. Matsepuro, Mr. A. S. Mayat, Mr. K. S. Nazarenko, Mr. A. V. Pukhalsky, Mr. N. P. Zvolinsky — Members of Soviet Agricultural Delegation.

The following 11 parties visited the Station: —

| | | |
|---|---|---|
| 21st April | ... | Staff and post-graduate students from the Horticultural Science Laboratories, Bristol University. |
| 3rd May | ... | Staff and students from the Agricultural Botany Department of Reading University. |
| 13th June | ... | Members of the Tysoe and District Young Farmers' Club, and members of the Leamington Spa Horticultural Branch of the National Farmers' Union. |
| 22nd June | ... | Staff and students from the Hertfordshire Institute of Agriculture. |
| 5th July | ... | Party of Warwickshire growers. |
| 12th July | ... | N.F.U. Vegetables Committee. |
| 19th July | ... | Staff and students from the Horticulture Department of Reading University. |
| 21st July | ... | Members of the Association of Applied Biologists. |
| 28th July | ... | N.A.A.S. Horticultural Advisory Officers. |
| 10th August | ... | Staff and students from Birmingham University. |
| 30th August | ... | Party of Horticultural Instructors from the Department of Agriculture, Dublin. |

**Acknowledgments**

Acknowledgment is made to the Agricultural Land Commission for assistance in carrying out some of the farming work at Paglesham.

Special thanks are due to members of the staff who have carried out duties in addition to their normal work. Mr. Winter continued to assist in connection with the fittings and services in the new buildings and Mr. Roberts again supervised the library. A Glasshouse Committee, Dr. Haigh, Dr. Keyworth, Mr. Norwood (Chairman), Mr. Winter and Mr. Wright, gave assistance in matters concerning the new glasshouses. The Canteen Committee consisted of Miss Beardall, Miss Bowe, Miss Smart (Secretary), Mr. Bridgewater (Chairman), Mr. Channon and Dr. Johnson (Treasurer). Miss Beardall was elected as Chairman when Mr. Bridgewater resigned at the end of March. This Committee had a heavy year's work owing to the greatly increased use made of the new canteen. Miss Baggs and Mr. Nelder assisted in the editing of this Annual Report.

Grateful acknowledgment is also made to other members of the staff who helped in various ways, and to all the staff and employees for the loyal manner in which they carried out their work during the year.

Thanks are due to the Executive Committee and the Sub-Committees, and especially to the Chairman of the Governing Body and the Chairmen of the Committees for the assistance they have given. We are sorry to have lost the services of Mr. F. A. Secrett who resigned from the Governing Body in April 1955 ; he gave valuable help as Chairman of the Farm Management Sub-Committee until 1951 and as Chairman of the Buildings Sub-Committee.

Thanks are also given to all those friends of the Station, particularly growers and commercial firms, who have kindly donated books, seeds, plants and other material, and who have helped in many other ways.

J. PHILP,

*27th January* 1956.

# PLANT BREEDING REPORT

By J. C. HAIGH

## Breeding Projects

The exploratory stage of the projects with lettuce and red beet has been completed and this report describes the breeding work begun with those crops. The third trial with spring cabbage brings the same stage to an end and the second trial with forcing radish has largely confirmed the conclusions formed from the first.

### *Lettuce*

The object of the lettuce project is to breed for resistance to the common diseases, in particular mosaic, downy mildew (caused by *Bremia lactucae* Regel), *Botrytis* and tip-burn. Observations made under field conditions over the past three seasons have not disclosed immunity from any of these diseases in the material examined. There has been comparatively little attack by *Bremia* or *Botrytis cinerea* Fr., but mosaic and tip-burn have been fairly common and Mr. Watts has found considerable differences in the degree to which varieties have suffered from these complaints. In the early days of this project the lack of suitable facilities made the artificial production of epidemics impossible, and material was therefore selected for further work on the basis of natural infection in the field. Under these conditions, the varieties showing least attack by the mosaic virus were three crisp types, namely, Lincoln Giant, Greatheart and 45634M, the last being a seedling bred by Dr. T. W. Whitaker of California which is believed to be immune to downy mildew. These three varieties, together with a wild species, *Lactuca altaica* Fisch and Mey, and a few more varieties which showed little attack by mosaic, were used to make a series of crosses which were taken to the $F_2$ stage before being exposed to attack in the field. This $F_2$ generation was grown in 1955, interplanted with susceptible varieties which had been mechanically inoculated with the mosaic virus. The fine weather throughout the summer greatly helped the spread of the virus by aphids, and out of a total of some 3,500 plants, only 58 plants were selected as being free of mosaic. These plants were selfed and the resultant $F_3$ progeny will be tested by the same method in 1956.

Complete control of lettuce mosaic demands immune material and is the ideal to be sought ; nevertheless a very large measure of control would be obtained if the carrying-over of the disease from one growing season to the next could be prevented. This carrying-over is commonly believed to be achieved by means of infected seed ; Couch (1) has found that the variety Cheshunt Early Giant does not transmit mosaic in this way, and it is being used as a parent in an attempt to transmit this desirable character to other cultivated forms.

A collection of summer lettuce types was grown in order that novelties, appearing for the first time in the 1955 catalogues, could be more easily classified. The dry summer and the consequent heavy attack of root aphid provided some interesting data on the reaction of varieties to this pest. Many plants died, and those which had started to bolt when the attack became heavy suffered less than those still in the hearting stage. Of the varieties which were hearting when the attack was at its worst, the following suffered least and produced a marketable crop : White Favourite (Barr) an All the Year Round type ; Midas, an American White Boston type ; Salad Bowl, an American Leaf lettuce ; and Reine de Glaces (Vilmorin) a 'Curly Crisp' type. Borough Wonder and Webb's Wonderful, the most commonly grown British varieties, succumbed completely just prior to maturity.

Mr. Watts again visited the Continent to study collections of lettuce varieties in France, Germany and the Netherlands. In collaboration with workers in those countries the survey of lettuce varieties has been extended to cover frame and winter lettuce. In the winter of 1954-55, 102 frame varieties were grown at Wellesbourne and were divided into 34 distinct types. The May Queen type formed the largest group ; it contained 13 names and in addition there were three single-variety groups

which approximated very closely to the same type. As with the summer lettuces, most of the varieties were very uniform, but there were intriguing exceptions. Four named varieties were each found to be a mixture of three well-defined forms and these forms occurred in very similar proportions in each of the four varieties.

In a trial with winter lettuce, 84 varieties were reduced to 16 distinct types. The most popular winter variety, judged by nominal diversity, was Imperial or Merveille d'Hiver with 20 synonyms. The well known Stanstead Park type had 10 names. A variety which appears to have no British synonym but should be worth a trial in this country is Neusiedler. It is rather similar to Imperial and matures at approximately the same time, but forms a more solid head of extremely neat appearance.

*Red Beet*

The heterozygous nature of a beetroot crop makes the use of the term 'synonymous' unwise when comparing two varieties ; 'of common origin' is perhaps better. To make matters more difficult, a few varieties have had the disconcerting feature of falling into different groups in different years. For example, Mr. Holland grew in 1955 a collection of one representative of each of the 33 sub-groups into which the collection had been divided, so as to have standards against which to compare nine novelties offered in the current catalogues. In order to establish this collection, fresh seed was bought, in each case from the same seedsman who had supplied it previously, and in no fewer than eight cases the 1955 crop was placed in a sub-group different from the one it was supposed to represent. Fortunately each could be placed in an existing sub-group, but the result was that the type collection was incomplete.

The objectives of the breeding project are uniformity, good colour, absence of rings, and freedom from bolting when sown early. All these qualities have been found separately in one or other of the varieties grown and attempts are now being made to combine them. Susceptibility to bolting following early sowing appears to be confined to the globe beets, and plants are being subjected to extra-early sowing and continuous daylight in order to encourage bolting. The method was successfully used by Bateson (2) with sugar beet. Seeds were sown in January and February and newly-germinated seedlings were subjected to continuous daylight for three weeks. At the end of the treatment period both treated seedlings and untreated controls were pricked out into boxes and kept in Dutch lights until they were put out into the field early in May. The effect of the treatments on bolting is shown in the following table ; the non-bolters were lifted in the autumn and will be seeded in 1956.

| Treatment | No. of plants raised | Days from sowing | | Non-bolters | |
|---|---|---|---|---|---|
| | | first bolter | last bolter | No. | % |
| Sown 26th Jan. and light treated | 297 | 129 | 161 | 0 | 0 |
| Sown 26th Jan. and NOT light treated .. .. .. | 296 | 138 | 171 | 0 | 0 |
| Sown 18th Feb. and light treated | 240 | 127 | — | 19 | 7.9 |
| Sown 18th Feb. and NOT light treated .. .. .. | 265 | 132 | — | 32 | 12.1 |

Sowing in January appears to have been too early since all plants bolted, and continuous daylight increased the amount of bolting in the February sowing, though it did not appreciably accelerate the onset of bolting.

American workers (3) have found a recessive gene in sugar beet which produces a single-seeded fruit instead of the normal multi-seeded form, and have transferred the character to red beet. With the gene for the monogerm character is linked a recessive gene which inhibits bolting and the material also contains a dominant gene for self-fertility. Eight small plants of this red beet material were obtained in February 1954, through the kindness of the Plant Breeding Institute, Cambridge. They were given a cold stimulus and set selfed seed in the same year ; the small quantity of seed was sown at once in order to produce flowering plants in 1955 and these were again selfed to produce sufficient seed to test the non-bolting character in 1956. The plants were also crossed in 1954 with a good strain of Detroit. The hybrid seed was sown in December 1954 and gave flowering plants in 1955, which were selfed, and were also back-crossed to Detroit in order to introduce the non-bolting and other characters into a good globe variety.

Male-sterile sugar beet material has been obtained from America and will be used to transfer this character to red beet.

### *Spring Cabbage*

The results of Dr. Johnson's trials with varieties of spring cabbage over the past three years are given later in this report.

During the 1954-55 season 87 varieties were grown. They were planted out, as in the 1953-54 trial, in two series, one spaced at 18 × 9 inches and put out at the beginning of September for cutting as greens, and the other planted a fortnight later at 18 × 18 inches for development into hearted cabbage. Both plantings were made in a randomised block layout and both produced a reasonable crop. It was reported in 1954 that the varieties fell into 19 morphological types. The present trials showed, however, that the number of groups could be reduced to 17. Four of these groups contained eight types unusual in commercial cultivation in this country (including the five Continental varieties in the 1954-55 trial) and will not be considered further. Of the remaining 13 groups, the largest contains 14 varieties of which Rous Lench and Early Offenham are typical, and most of the other groups contain between three and twelve varieties. In the 1955 'greens' trial, 13 varieties were found to be significantly better in performance than the rest, and seven varieties were significantly better than the others in the trial with hearted cabbage. One variety only, Early Market 218 (Clucas) was among the highest yielders in both the 'greens' and 'hearted' trials, though it was not the best individual performer in either trial. Plants have been selected from these superior varieties and from disease resistant varieties to be used as breeding material for the production, if possible, of an improved dual purpose spring cabbage.

### *Forcing Radish*

Mr. Watts has continued his examination of forcing radish and grew 110 varieties in 1955. The number of groups of similar varieties has been reduced from 12 to 10 as a result of further study. The Scarlet Globe group now includes 48 varieties, the French Breakfast group 17, the Long Red and Long White 9 each and the remaining 27 varieties are divided among 6 small groups. Although there is considerable variation within any one variety, root shape and colour are sufficiently uniform to make classification possible, and by a combination of roguing and inbreeding it is hoped to produce a marked improvement in uniformity.

### *Asparagus*

Work is in hand to produce seed of asparagus which will give a population of male plants instead of the approximately equal numbers of male and female plants produced by normal seed. The method was suggested by Rick and Hanna (4) in America and has been demonstrated by Sneep (5) in the Netherlands. The collaboration of Mr. Adam Howley of Littleton, the Evesham and District Asparagus Growers' Association, and the N.A.A.S. horticultural staff for Worcestershire is gratefully acknowledged.

**Breeding Methods**

*Brassicas*

Dr. Johnson has continued the inbreeding programme with Brussels sprouts. The $S_2$ generation raised from selected $S_1$ plants of Cambridge Special is now mature. There are small but obvious differences between lines from different $S_1$ plants, but variation within lines is very slight. There is little difference in size between $S_1$ and $S_2$ plants, each having about 75 per cent of the leaf area of the parent stock.

The $S_1$ lines which last year produced up to 80 per cent bolters were sown again in 1955, but one month later, and gave only 10–15 per cent bolters, indicating the influence of environment (probably temperature) on bolting. On the other hand, progenies from selfed bolters have given from 2–20 per cent bolters whereas progenies from non-bolters sown at the same time have given no bolters, indicating that the tendency to bolt is genetically controlled.

The attempt to determine the type of incompatibility system operating in Brussels sprouts is made more difficult by the widespread occurrence of self-fertility. It has been known for some time that self-fertility was present in varying degree in different plants of a population (6) but precise data were lacking. In the course of producing nucleus stock seed of the variety Cambridge No. 3, a branch on each of 39 plants was self-pollinated. Eight plants were effectively self-incompatible ; the remaining 31 each produced five or more seeds per 100 flowers, and 14 of these plants each gave 50 or more seeds per 100 flowers selfed. The highest yield obtained was 1,200 seeds per 100 flowers selfed, which approaches complete self-fertility.

Inbred lines from the above 39 plants of Cambridge No. 3 were grown in 1955 and compared with progenies produced from the same plants by mass pollination. There was much variation between these inbred lines in such important characters as plant type and size, sprout quality and yield, and in some cases there were wide differences between an inbred line and the progeny produced from the same parent by mass pollination. There was little inbreeding depression, and inbred lines were relatively uniform.

*Onion*

The work hitherto done by Mr. Holland with onions has been confined to the maintenance of nucleus stock seed of the Cambridge varieties No. 2 (flat) and No. 10 (globe), and the testing of many seedling strains taken over from the Horticultural Research Station, Cambridge. More recently, however, he has begun work on the introduction and use of male sterility as a tool in the production of uniform high-yielding hybrids.

The production of hybrid onions by the utilisation of male sterility is now commercial practice in America. Seed of a number of American hybrid lines was generously supplied by Dr. H. A. Jones of the United States Department of Agriculture, who pioneered the production of hybrid onions in America. This material was used to transfer the male-sterile character into some of the Cambridge lines and also to test the genetic constitution of those lines. Incidentally, one of the American varieties has produced a very promising hybrid with one of the Cambridge seedlings, and this and other hybrids will be tested under field conditions in 1956.

Functional male sterility, caused by non-dehiscence of the anthers, was found in 1954 (6) in plants of Cambridge No. 10 growing in a cold house. Similar plants grown in the field in 1955 have indicated that the mechanism is imperfect ; under some environmental conditions, not yet precisely determined, the anthers do split slightly so that a little pollen is exposed.

What appears to be cytoplasmic male sterility has been found in 1955. In one plant out of 200 of Cambridge No. 10, three out of 68 in Cambridge No. 2 and two out of 61 in a seedling line, the flowers appeared to have no pollen, and microscopic examination of squashed anthers showed only shrivelled and empty pollen grains. Seed produced by crossing with male-fertile plants will be used to determine the nature and mode of inheritance of the pollen sterility. The advantages of having 'ready-made' male sterility in our own inbred material are obvious. The greater part of the

imported American material, while of the greatest value for breeding purposes, proved to be indifferent in performance under our conditions, bolting in the field and rotting in storage.

Blow-flies have again been used as pollinators with marked success. For pair crosses or selfs, small muslin bags were used in the glasshouse; for larger numbers of plants, nylon cages were used out of doors; in both cases, better seed sets were obtained than by hand pollination under glass, and more breeding lines could be seeded in isolation.

**Seed Production**

Nucleus stock seed was produced of the following varieties which are on the market or are undergoing trials :—

| | | |
|---|---|---|
| Brussels sprouts .. .. .. | Cambridge No. 1 | at Wellesbourne |
| Onion .. .. .. .. | Cambridge Nos. 2 and 10 | |
| Winter cabbage .. .. .. | Cambridge February | at Paglesham |
| Early cauliflower .. .. | Cambridge No. 7 | |
| Winter cauliflower .. .. | Cambridge Dwarf April | |
| Onion .. .. .. .. | Cambridge No. 10 | |

Plants were grown for selection and the production in 1956 of nucleus stock seed of the following varieties :—

| | | |
|---|---|---|
| Brussels sprouts .. .. .. | Cambridge Special | at Wellesbourne |
| Onion .. .. .. .. | Cambridge Nos. 2 and 10 | |
| Winter cabbage .. .. .. | Cambridge Red | at Paglesham |
| Onion .. .. .. .. | Cambridge No. 10 | |

**Work at Outside Centres**

Seed has been collected from selections made at Rosewarne E.H.S. of plants of Roscoff broccoli heading in the period February/March. A yield trial with some breeding lines of winter cauliflower of a type similar to Cambridge Dwarf April was planted at Efford and Luddington E.H.S. At Luddington none of the lines was better than Cambridge Dwarf April and at Efford the trial was spoiled by a bad attack of ringspot (caused by *Mycosphaerella brassicicola* (Duby) Oudem.) to which the material was susceptible. Yield trials with breeding lines of onions were sown at Efford, Luddington and Stockbridge House E.H.S. We are grateful for the ready collaboration of the Directors and staffs of all the above E.H.S.

**Miscellaneous**

Flowering in Brussels sprouts has been inhibited by keeping the plants at a temperature of 60°F. between the beginning of November and the end of May. Cuttings were taken from selected plants in the field at monthly intervals from October to March and were rooted and grown in temperatures of 60°F. and 70°F. in the glasshouse. Those brought into the glasshouse up to the beginning of November did not produce flower buds; those brought in from early November to mid-December produced buds in March, but the buds aborted; and those brought in after Christmas flowered in due course, though there was some abortion in the buds of the plants kept at 70°F. The higher temperature, however, was detrimental to the health of the plants and many died. At 60°F. it was found necessary to supplement the daylight at the rate of 15 watts per square foot by means of 500-watt mercury vapour/tungsten lamps.

Bees are now widely used for pollinating plants under glass for seed production, but losses of bees are usually high. With the collaboration of Dr. C. G. Butler of

Rothamsted, a technique has been devised which uses hives of bees to pollinate small numbers of plants under nylon-screen cages in the open, without a serious mortality rate among the bees. A note on the technique is being prepared for publication.

Small colonies of bees are also being used for making pair crosses between cauliflower plants under nylon cages in the field. Cauliflower and broccoli react badly to being transplanted when they are mature, and in consequence a poor seed set is frequently obtained. By alternating plants of two varieties in both directions in field plants, it is usually possible to find adjacent plants which are suitable for crossing. The two plants are covered by a nylon cage and nucleus colonies of bees are introduced to do the pollination.

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# SPRING CABBAGE VARIETIES

## THEIR CLASSIFICATION AND PERFORMANCE

By A. G. JOHNSON

## INTRODUCTION

Trials of spring cabbage varieties were conducted at the N.V.R.S., Wellesbourne, as a preliminary to a breeding programme. The information which was obtained on the morphological range of the material available and the cropping performance of the various types is presented in separate sections of this paper.

Spring cabbage is sown in July or August, planted in the early autumn, and is mature in the following spring. Thus the plants must be winter hardy, resistant to early bolting, and capable of rapid growth when conditions are favourable. Suitable types generally have a conical or cylindrical heart. Within each type there are many varieties and these resemble one another in general morphological characters. The crop is chiefly grown in Britain and North Western Europe, though a few similar types of cabbage exist in the U.S.A., and a collection of 130 varieties from these sources was grown at this Station during the season 1952-53. This collection included all differently named British varieties listed in catalogues available to us. Thirty varieties, mainly foreign, were discarded after the first season as being entirely unsuitable for British conditions. The remainder were grown in trials during the seasons 1953-54 and 1954-55.

Catalogues were put in a random order and any particular name was taken from the first catalogue in which it appeared. Thus the trials did not include a range of seedsmen's stocks of each variety. The names of the firms supplying the seed are included in the classification list, so that misconceptions about strains may be avoided.

Spring cabbage is normally cross-fertilised and hence the material is very heterozygous. This results in a great deal of variation, but in most varieties selection for a particular type has confined the variation within certain accepted limits. Even so, variation is such that dissimilar varieties may overlap near these limits. Moreover, selection (whether natural or artificial) within a variety over the course of several generations may modify one or more characters whilst leaving the rest unchanged. As a result, morphologically similar varieties may differ in such characters as disease resistance or yield, and may be regarded as strains within a variety.

## CLASSIFICATION

Varieties have been divided into five *classes* (Roman numerals) according to maturity date. These classes were divided into *forms* (Arabic numerals) according to heart shape. The class-form combinations were further sub-divided into *groups*, denoted by capital letters, on the basis of minor characters. By reason of the variation, as described above, varieties within groups are morphologically similar, but not identical, and therefore cannot be described as synonyms.

During the season 1952-53 my colleague, Mr. L. E. Watts, obtained and grew the varieties listed and was able to divide them provisionally into some 25 to 30 categories according to their heart shape and period of maturity. During the two subsequent seasons it has been possible to define 17 major groups containing 86 varieties, the remaining varieties being unsuited to the environment and failing to produce classifiable mature plants.

### Characters studied for classification

(a) *Date of maturity as a marketable hearted cabbage*

The date of maturity was based on the peak cut, that is, the date at which the greatest number of heads were mature at one time. Data of peak cut do not take into account differences of less than one week, since cutting could only be done at weekly intervals, and in addition they do not indicate the length of the maturity period.

Because of these shortcomings of the peak cut date, notes on the maturity period are included where necessary in the group descriptions. The range of maturity covered by the different varieties was divided into five classes—very early, early, mid-season, late, and a class in which few plants ever attained a marketable stage. The number of days from sowing to peak cut given in the classification list is the mean period for each group of similar varieties.

(b) *Shape of heart*

Almost all British varieties have a conical heart at maturity but the cone varies in length and width, giving all combinations from short and broad to long, thin and almost cylindrical. In addition to the conical form of heart, a few varieties from France, Germany and Denmark have an elliptical heart similar in shape to a Rugby football. Five heart forms were distinguished by eye—broad conical, long narrow conical, conical tending to elliptical, pointed elliptical, and elliptical. Measurements of heart dimensions confirmed this classification.

(c) *Size of mature plant*

Plant size, judged both by eye and by weight of heart, in general was correlated with date of maturity, in that the earliest varieties were the smallest and the later ones were the largest. It should be noted, however, that size was not necessarily proportional to weight, owing to varying density of the hearts.

(d) *Form of leaves*

Many varieties may be characterised by the form of the leaves immediately surrounding the heart. These may be tightly attached to the heart, forming a smooth sheath, or may show various degrees of looseness, particularly at the apex, reaching an extreme in which the hearts appear to be surrounded by a hood or cowl. The foliage of varieties in group P was similar to that of January King cabbage, the leaves being deeply crinkled and frilled, whereas leaves of all other varieties were smooth and entire.

(e) *Colour of leaves*

The colour ranged from a pronounced yellow-green to a deep blue-green. In most varieties the outer leaves of the heart were lighter in colour than the basal leaves, and this was particularly marked in the early groups where many varieties had almost cream coloured hearts. Apart from this, the colour of both heart and basal leaves varied considerably within and between varieties and did not provide a satisfactory character for classification.

(f) *Other characters*

Among the other characters studied were winter hardiness, susceptibility to disease, tendency to early bolting, and the number of non-heart leaves. Winter hardiness and susceptibility to disease were found to be associated more with strain than with type and were therefore of no great help in the main classification. All varieties were sown on each of two dates, namely as near as possible to 18th July and 1st August, and when sown at the earlier date the very early and the late varieties showed a high proportion of premature bolting. It was also found that, in general, the later the variety, the greater the number of non-heart leaves. Measurements were made of a number of characters such as plant width, plant height, leaf size, and leaf shape. The spread of the frequency distribution curve obtained from a sample of plants within a variety was so great for all these characters that the data were of no value in classification.

(g) *Seedling characters*

With a few exceptions, no correlation was found between the characters of the seedling and the type of the mature plant. The small varieties (Groups A and AA) tended to have small seedlings of weak appearance, and the larger varieties (Groups H, K, O and P) had rather strong vigorous seedlings. Group P, with crinkled and frilled mature foliage, showed this character in the seedling.

**Classified List**

(For ease of reference by varietal name, an alphabetical index is included in the appendix).

**Class I. Very early maturity**

*Heart Form* 1—*short, conical and broad at base*

Group A

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Conqueror | D. T. Brown | Witham Wonder | Cooper Taber |
| First Crop | D. T. Brown | | |

Small to dwarf at maturity. Heart remains marketable only for a very short time before bursting. Colour of basal leaves rather pale green, heart colour yellow-green to cream. Average heart weight 1 lb., but could probably produce these hearts at nine-inch-square spacing. Unsuitable for early sowing owing to excessive bolting following a hard winter. Days from sowing to peak cut as hearted cabbage, about 283.

Sub-Group AA

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| First of All | Webb | Southampton Wonder | Toogood |
| Foremost | Fogwill | Superfine | Pennel |
| Harbinger | Hurst | Wheeler's Imperial | Hurst |
| Maincrop | Ryder | | |

Very similar to Group A and contains many plants which are identical with plants in group A. In general, however, slightly larger and later than A, though still similar in type and characteristics, particularly the early bursting of hearts. Average heart weight 1.7 lb. Days from sowing to peak cut as hearted cabbage, about 286.

**Class II. Early**

*Heart Form* 1—*short, conical and broad at base*

Group B

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Covent Garden | Fogwill | Myatt's Early Offenham | Tozer |
| Early Feltham | Watkins & Simpson | Nonesuch | Toogood |
| Early Kent | Harrison (*Leicester*) | Queen of Spring | J. K. King |
| Early Market | Hurst | Rous Lench | Speed |
| Early Perfection | Woodward | Severn Stoke (Local) | Stokes (*Evesham*) |
| Early Queen | E. W. King | Springtide | Unwin |
| Myatt's Early Offenham | Hurst | Wrench's Queen of Market | Cooper Taber |

Medium to large at maturity. Contains occasional plants similar to those of group A but, in general, plants are larger than those of AA, a little later, have a better colour and burst less readily. This group can be recommended for commercial use, and is suitable for early sowing. Average heart weight 1.7 lb. Days to peak cut as hearted cabbage, about 287.

Sub-Group BB

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Advance | Woodward | Sleaford Market | Sharpe |
| Durham Early | Clucas | | |

Similar in type to group B but larger, with rather more outer leaves of a slightly coarse appearance. Contains a few plants of the group A type. Colour fair to good, hearts rather loose, and stands mature for about the same time as group B. Average heart weight 1.5 lb. Suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 287.

**Class III. Mid-season**

*Heart Form* 1—*short, conical and broad at base*

Group C

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Emperor | Webb | Tender and True | Clibran |
| Milecross Marrow | Dickson (*Hawlmark*) | | |

Medium size. Smaller and more compact than group B and slightly later, but heads stand mature for much longer period. Colour good. Average heart weight 1.7 lb. Not recommended for early sowing. Days from sowing to peak cut as hearted cabbage, about 287.

Group D

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Early Paragon | Speed | First Early | E. W. King |

Large and leafy. Leaves rough and corrugated. Basal leaves very dark in colour but heart rather lighter shade and only fair colour compared with other groups. Average heart weight 1.9 lb. Suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 295.

Group E

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Carrington Early Market | Dickson, Brown & Tait | Foremost | Unwin |
| | | Knowefield Early | Little & Ballantyne |
| *Early Giant | Sutton | *Market Favourite | Finney |
| *Early Wonder | Finney | *Offenham Hardy Strain | Watkins & Simpson |
| Early Wonder | Fogwill | Spring Glory | D. T. Brown |

A medium large type with a good solid heart, which stands without bursting for a considerable period. Heart shape mainly Form 1, but rather variable within varieties. Average heart weight 1.9 lb. Approaching in type the rather large coarse-looking varieties finding favour in northern but not southern markets. Only the four varieties marked by an asterisk are suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 303.

Group F

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Beefheart | Carter | Heartwell | Cooper Taber |
| Earliest of All | Unwin | Imperial | Webb |
| Flower of Spring | Sutton | Spring | Bees |

Medium to large size, rather loose heart. Leaves immediately surrounding heart form a 'hood' at apex. Average heart weight 2 lb. Tending to type for northern markets. Can be sown early but this is not recommended. Days from sowing to peak cut as hearted cabbage, about 303.

Group G

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Ideal Early | Yates | May Day | Dickson (*Hawlmark*) |
| Little Pixie | Sharpe | Number One | Finney |

Very similar to group E but distinguished by being slightly larger and later. Average heart weight 1.6 lb. Days from sowing to peak cut as hearted cabbage, about 303.

Group H

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Criterion | Barr & Sons | Leader | Dunn |
| Early Gem | Bunting | Liverpool Market | Finney |
| Early Market 218 | Clucas | Newcastle Market | Finney |
| Early Spalding | Elsom | Spalding Market | Elsom |
| Excelsior | Dickson (*Hawlmark*) | Twelve Weeks | Ryder |

Large with rather loose heart. Colour fair to good but leaves of rather coarse appearance. A type better suited to the northern market. Average heart weight 1.8 lb. Suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 306.

**Class III**

*Heart Form* 2—*long, conical and narrow at base*

Group J

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| *Cooper's First Early Invincible | Cooper Taber Speed | *Emperor | Toogood |

Medium size. Rather coarse and somewhat similar in appearance to group BB, but later and somewhat larger. Colour good, dark green. Average heart weight 1.9 lb. The two varieties marked by an asterisk are suitable for early sowing and are recommended for winter hardiness. Days from sowing to peak cut as hearted cabbage, about 290.

Group K

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Best of All | Fogwill | First and Best | Hurst |
| *Dwarf | Barr & Sons | New Leader | Webb |
| *Early Exhibition | Woodward E. W. King | Springtide | Carter |

Large, rather loose, and coarse in appearance. Leaves immediately surrounding heart form a point at apex. More suited to the northern market. Average heart weight 1.7 lb. Only the two varieties marked by an asterisk are recommended for early sowing. Days from sowing to peak cut as hearted cabbage, about 306.

**Class III**

*Heart Form* 3—*conical, tending to elliptical, broad at base*

Group L

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Coconut | Sharpe | Favourite | Webb |

Small to medium size. Resembles group B but later. Average heart weight 1.5 lb. Suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 303.

**Class III**

*Heart Form* 4—*elliptical but pointed at apex*

Group M

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Early McEwan | Scarlett | Early Triumph | Sharpe |

Medium size. Colour only fair, rather pale. Average heart weight 1.5 lb. Early Triumph is not suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 287.

**Class III**

*Heart Form* 5—*elliptical heart*

Group N

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Précoce des Marchés | Vilmorin (France) | Très hâtif d'Etampes | Vilmorin (France) |

Medium size, rather loose. Very crisp leaf texture, colour rather yellowish and leaf surface shiny. An unusual type not likely to find acceptance on British markets. Average heart weight 1.6 lb. Unsuitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 312.

**Class IV. Late**

*Heart Form* 1—*short, conical and broad at base*

Group O

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| East Ham | Cooper Taber | Improved Bullock Heart | Clucas |

Very large, leafy and coarse. Hearts loose. Colour very dark green. Average heart weight 1.4 lb. Unsuitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 315.

**Class IV**

*Heart Form 2—long, conical and narrow at base*

Group P

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Bacalan Gros | Vilmorin (France) | Chou de Chavannes | Samen Müller (Switzerland) |
| Bacalan hâtif | Vilmorin (France) | | |

'Curly' type. Large, leafy, very late. Colour pronounced blue-green, leaves deeply corrugated with frilled edges. Heart is large and solid with an average weight of 1.8 lb. All have a tendency to premature bolting. Not suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 315.

**Class IV**

*Heart Form 3—conical tending to elliptical, broad at base*

Group Q

| Variety | Supplier |
|---|---|
| Erstling Hunderup P.1945 | Daehnfeldt (Denmark) |

Very similar to group N but later and more conical heart. Average heart weight 1.6 lb. Strong tendency to premature bolting, and unsuitable for early sowing. Erstling and Greyhound, however, are said to be synonymous and Greyhound is recommended by suppliers for spring sowing. Days from sowing to peak cut as hearted cabbage, about 315.

**Class IV**

*Heart Form 4—elliptical but pointed at apex*

Group R

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Cotswold Queen | Hurst | Nonpareil | Hurst |
| Erstling | Dippe (Germany) | | |

The three varieties are not strictly similar morphologically but are of the same general type and quite unlike any other. All these varieties have a strong tendency to bolting, Nonpareil not being recommended for autumn sowing by the suppliers. It would appear that these varieties might do better if sown in spring. All are dwarf and are more 'novelty' garden types than commercial types. Average heart weight 1.3 lb. Not suitable for early sowing. Days from sowing to peak cut as hearted cabbage, about 315.

**Class V. Unsuitable for sowing in July–August.**

The varieties listed below either remain open and leafy, or bolt prematurely, and for these reasons might be better if sown in spring. Nevertheless, Enfield Market is widely grown by amateurs because of the bulk of leaf it produces.

| Variety | Supplier | Variety | Supplier |
|---|---|---|---|
| Charleston Wakefield | Asgrow (U.S.A.) | Jersey Wakefield | Asgrow (U.S.A.) |
| Chou Express | Samen Müller (Switzerland) | Nantais hâtif (Joanet) | Vilmorin (France) |
| Colewort (grown only as a 'leaf' variety) | Hurst | Perfection | Ryder |
| Coeur de Boeuf de Jersey | Vilmorin (France) | Pommé Plat de Paris | Vilmorin (France) |
| Coeur de Boeuf Gros | Vilmorin (France) | Très Précoce à Grosse Pommé | Vilmorin (France) |
| Enfield Market | Hurst | Wakefield | Daehnfeldt (Denmark) |
| Express | Vilmorin (France) | Winnigstadt | Woodhead |

## YIELD AND PERFORMANCE TRIALS

### Culture

In the seasons 1953-54 and 1954-55 all varieties were sown in seed-beds on each of two dates, namely as near as possible to 18th July and 1st August. The first sowing was planted out at a spacing of 18 inches between rows and 9 inches between plants about the first week of September, and the second was planted out at 18×18 inches about the middle of September. In 1953 the crop followed barley and had 6 cwt. per acre of a basic fertiliser, 9N : 9P : 15K, applied before planting. A top dressing of 4 cwt. per acre of nitrochalk was given at the end of January and a further 4 cwt. at the beginning of April. In 1954 the crop followed a ley and had 15 tons per acre of FYM ploughed in, together with 4 cwt. of basic fertiliser. A top dressing of 6 cwt. of nitrochalk was applied in early February. Cultivations, etc., were normal for the district.

### Experimental method

In the 1953-54 season, each variety in each sowing was represented by a plot containing two rows of 60 plants each. One row was cut and the other row was retained for observations relating to classification. In the 1954-55 season, the trials, one for each sowing date, were laid out in the form of four randomised blocks of plots, each plot consisting of two rows of 30 plants in each.

All varieties from the first sowing were cut as soon as about one-third of the varieties were sufficiently developed to give an average commercial crop of 'spring greens', and all plants were cut irrespective of size, except for those which were completely unmarketable. The number of plants cut and the weight of produce were recorded, together with numbers of gaps, off-types, diseased heads and bolters. Colour and quality were also scored. Similar data were taken when plants from the second sowing were mature, but in this case the harvesting procedure was different in that no heart was cut until it was ready for market. Thus the hearted cabbage were harvested in a series of cuts.

The colour score was based on the depth of green colouring at the time of cutting, and the quality score on the general attractiveness or otherwise of the sample.

### Results

Summaries of the results obtained are given in Tables I and II. For ease of comparison, all yield figures have been converted to the equivalent pounds weight per acre at the spacings given. These figures, of course, are likely to be higher than those which would be obtained in normal large-scale commercial practice. The more outstanding performances for the various characters have been printed in heavy type, the basis of such marking being given at the foot of the tables.

In the 1953-54 season, a period of exceptionally hard and sustained frost occurred at the beginning of February, following several weeks of mild weather which had caused the plants to re-commence growth. During the first week of February the temperature rarely rose above freezing point, the lowest ground temperature recorded being equivalent to 21 degrees of frost. Whilst this gave an excellent opportunity for observing frost resistance and premature bolting (which is accentuated by a severe winter) it resulted in a complete loss of yield in many varieties from the first sowing, and a reduction in yield in most varieties from the second sowing.

Since yield data for spring greens from the 1954 harvest were incomplete, they are excluded from Table I. They showed, however, a general agreement with those obtained in 1955 regarding the relative merits of varieties. The percentage of diseased heads formed a measure of the amount of frost damage suffered by the varieties, since rotting, caused chiefly by *Botrytis*, invariably followed severe frost damage. Only rarely did rotting occur for any other reason. The observations on bolting in the 1953-54 season are of great value, since any variety showing little or no bolting in that season can be considered as almost immune. Several varieties with little bolting in 1954-55 bolted severely in 1953-54 and although these would crop successfully in an average season, they might give a severe loss after an exceptionally hard winter.

The 1954 yield figures for hearted cabbage in Table II were more complete than those for 'greens'. It should be noted, however, that yields in 1954 were generally lower than those in 1955. In general, the earliest varieties suffered a greater yield reduction than the later ones owing to their being advanced in growth when the severe weather occurred. The proportion of the total yield which was obtained at the peak cut gives a measure of the variation in maturity period of plants within a variety.

TABLE 1

*Spring cabbage varieties. Yield and performance as 'spring greens' (early sowing). 1954-55.*

| Group | Name* | Marketable yield. 100's lb. per acre | % diseased heads | Bolting | | Colour score out of 10 | Quality score out of 10 |
|---|---|---|---|---|---|---|---|
| | | | | % of plants in 1954-55 | Degree in 1953-54 | | |
| A | All varieties } Not grown | | | | | | |
| AA | All but the two below } 1954-55 | | | Excessive | | | |
| AA | First of All ... ... | 109 | 5 | 1 | slight | 2 | 1 |
| AA | Wheeler's Imperial ... | 68 | 3 | 8 | severe | 4 | 1 |
| B | Covent Garden ... | 83 | 1 | 10 | severe | 3 | 5 |
| B | Early Feltham ... ... | 110 | 2 | 1 | slight | 1 | 2 |
| B | Early Kent ... ... | 109 | 2 | 0 | slight | 3 | 1 |
| B | Early Market ... ... | 114 | 3 | 2 | slight | 4 | 6 |
| B | Early Perfection ... | 123 | 2 | 2 | severe | 6 | 9 |
| B | Early Queen ... ... | 90 | 2 | 3 | moderate | 5 | 5 |
| B | Myatt's Early Offenham (Hurst) ... ... | 129 | 4 | 2 | severe | 3 | 3 |
| B | Myatt's Early Offenham (Tozer) ... ... | 135 | 3 | 1 | nil | 2 | 3 |
| B | Nonesuch ... ... | 109 | 1 | 0 | nil | 5 | 4 |
| B | Queen of Spring ... | 103 | 3 | 2 | severe | 1 | 1 |
| B | Rous Lench ... ... | 167 | 1 | 0 | very slight | 7 | 7 |
| B | Severn Stoke (Local) ... | 167 | 2 | 0 | nil | 8 | 10 |
| B | Springtide (Unwin) Failure due to bad germination 1954-55. | | | | very slight | | |
| B | Wrench's Queen of Market ... ... | 125 | 2 | 1 | moderate | 3 | 4 |
| BB | Advance ... ... | 119 | 3 | 3 | slight | 4 | 5 |
| BB | Durham Early ... | 145 | 3 | 0 | slight | 6 | 7 |
| BB | Sleaford Market ... | 99 | 6 | 1 | nil | 3 | 4 |
| C | Emperor (Webb) ... | 91 | 2 | 1 | severe | 4 | 5 |
| C | Milecross Marrow ... | 109 | 3 | 0 | moderate | 3 | 3 |
| C | Tender and True ... | 93 | 2 | 1 | slight | 2 | 3 |
| D | Early Paragon ... | 143 | 4 | 0 | moderate | 7 | 9 |
| D | First Early ... ... | 111 | 2 | 0 | slight | 7 | 7 |
| E | Carrington Early Market —not grown 1954-55 ... | — | — | — | excessive | — | — |
| E | Early Giant ... ... | 140 | 3 | 3 | moderate | 8 | 10 |
| E | Early Wonder (Finney) | 138 | 2 | 2 | moderate | 10 | 10 |
| E | Early Wonder (Fogwill) | 119 | 4 | 3 | nil | 3 | 1 |
| E | Foremost ... ... | 132 | 2 | 1 | severe | 5 | 7 |
| E | Knowefield Early ... | 138 | 1 | 1 | very slight | 5 | 4 |
| E | Market Favourite ... | 130 | 2 | 1 | moderate | 6 | 6 |
| E | Offenham Hardy Strain | 129 | 3 | 0 | moderate | 10 | 10 |
| | Key to heavy type ... | above 120 | 1% or less | no bolting | very slight or no bolting | 8 or above | 8 or above |

*For suppliers see classified list.

TABLE 1 (*continued*)

*Spring cabbage varieties. Yield and performance as 'spring greens' (early sowing). 1954-55.*

| Group | Name* | Marketable yield. 100's lb. per acre | % diseased heads | Bolting | | Colour score out of 10 | Quality score out of 10 |
|---|---|---|---|---|---|---|---|
| | | | | % of plants in 1954-55 | Degree in 1953-54 | | |
| E | Spring Glory ... ... | **132** | 6 | 2 | moderate | 5 | 5 |
| F | Beefheart ... ... | 120 | **1** | 3 | moderate | 3 | 3 |
| F | Earliest of All ... ... | 100 | 2 | 4 | severe | 4 | 4 |
| F | Flower of Spring ... | 103 | **1** | 1 | not grown | 5 | 5 |
| F | Heartwell ... ... | 95 | 3 | 1 | moderate | 5 | 5 |
| F | Imperial ... ... | 99 | 3 | 2 | **nil** | 6 | 4 |
| F | Spring—not grown 1954-55 ... ... | — | — | — | excessive | — | — |
| G | Ideal Early ... ... | **167** | 3 | **1** | moderate | 7 | **8** |
| G | Little Pixie ... ... | 110 | 3 | 1 | severe | 4 | 5 |
| G | May Day ... ... | **133** | 3 | 3 | severe | 7 | 6 |
| G | Number One ... ... | **122** | 3 | 1 | **very slight** | 1 | 3 |
| H | Criterion ... ... | **131** | 2 | 8 | severe | 6 | **8** |
| H | Early Gem ... ... | **123** | 2 | 1 | **very slight** | 6 | 7 |
| H | Early Market 218 ... | **147** | 3 | **0** | **very slight** | 3 | 6 |
| H | Early Spalding ... | **136** | 2 | **0** | **very slight** | **9** | **8** |
| H | Excelsior—not grown 1954-55 ... ... | — | — | — | excessive | — | — |
| H | Leader ... ... ... | 120 | **0** | 1 | moderate | **8** | 7 |
| H | Liverpool Market ... | **130** | 2 | **0** | slight | **3** | 6 |
| H | Newcastle Market ... | 116 | 2 | 0 | **very slight** | 6 | 5 |
| H | Spalding Market ... | 114 | **0** | 4 | moderate | 6 | 7 |
| H | Twelve Weeks ... ... | **132** | **1** | 4 | severe | 7 | **8** |
| J | Cooper's First ... ... | **123** | **1** | 4 | slight | 5 | 6 |
| J | Early Invincible—not grown 1954-55 ... | — | — | — | excessive | — | — |
| J | Emperor (Toogood) ... | 99 | **1** | **0** | **nil** | 6 | 6 |
| K | Best of All—not grown 1954-55 ... ... | — | — | — | excessive | — | — |
| K | Dwarf ... ... ... | **130** | 2 | 3 | **very slight** | 6 | 5 |
| K | Early ... ... ... | **162** | 2 | **0** | **very slight** | 3 | 7 |
| K | Exhibition ... ... | 112 | 3 | 1 | **very slight** | 6 | 7 |
| K | First and Best ... ... | **134** | 4 | 6 | moderate | 6 | 7 |
| K | New Leader—not grown 1954-55 ... ... | — | — | — | excessive | — | — |
| K | Springtide ... ... | 109 | 2 | 3 | severe | **8** | 5 |
| L | Coconut ... ... | 105 | 2 | 1 | moderate | 5 | 5 |
| L | Favourite ... ... | 108 | 2 | 3 | slight | 4 | 6 |
| M | Early McEwan ... | **130** | 2 | **0** | **very slight** | 5 | 4 |
| M | Early Triumph ... | 83 | 3 | 1 | severe | 2 | 3 |
| N, O, P, Q, R | Not grown 1954-55 ... | — | — | — | excessive | — | — |
| | Key to heavy type ... | above 120 | 1% or less | no bolting | very slight or no bolting | 8 or above | 8 or above |

*For suppliers see classified list.

## TABLE II

*Spring cabbage varieties. Yield and performance as 'hearted cabbage' (normal sowing). 1954-55.*

| Group | Name* | Marketable yield 100's lb. per acre | | Peak cut 100's lb. per acre 1954-55 | % plants never fit to cut (includes bolters) 1954-55 | % bolting | |
|---|---|---|---|---|---|---|---|
| | | 1954-55 | 1953-54 | | | in 1954-55 | in 1953-54 |
| A | Conqueror—not grown 1953-54 ... ... | 167 | — | 76 | **5** | 0 | — |
| A | First Crop ... ... | 177 | 96 | 82 | **3** | **0** | **0** |
| A | Witham Wonder ... | 178 | 91 | 73 | 16 | 6 | 0 |
| AA | First of All ... ... | **253** | 99 | **124** | **8** | **0** | **0** |
| AA | Foremost ... ... | 221 | 141 | 74 | **7** | **0** | **0** |
| AA | Harbinger ... ... | 187 | 125 | 71 | 18 | 8 | 0 |
| AA | Maincrop ... ... | 221 | 122 | 80 | **7** | 1 | 1 |
| AA | Southampton Wonder | 180 | 154 | 94 | 16 | 1 | 0 |
| AA | Superfine ... ... | 208 | 177 | 106 | 17 | 5 | 2 |
| AA | Wheeler's Imperial ... | 221 | **193** | **121** | **11** | 1 | 2 |
| B | Covent Garden ... | 122 | **181** | 51 | 30 | 2 | 1 |
| B | Early Feltham ... ... | **269** | 156 | **120** | **11** | **0** | **0** |
| B | Early Kent ... ... | **280** | 150 | **151** | **4** | **0** | **0** |
| B | Early Market ... ... | **297** | 61 | **167** | **7** | 1 | 0 |
| B | Early Perfection ... | 233 | **183** | 104 | 22 | 1 | 0 |
| B | Early Queen ... ... | 184 | 138 | 112 | 22 | 1 | 0 |
| B | Myatt's Early Offenham (Hurst) ... ... | 217 | 129 | 89 | **12** | 1 | 0 |
| B | Myatt's Early Offenham (Tozer) ... ... | 236 | 167 | 101 | **12** | **0** | **0** |
| B | Nonesuch ... ... | 244 | 125 | 109 | 17 | **0** | **0** |
| B | Queen of Spring ... | 203 | **191** | 119 | 14 | 2 | 1 |
| B | Rous Lench ... ... | 184 | **180** | 66 | 33 | **0** | **0** |
| B | Severn Stoke (Local) ... | 182 | 164 | 70 | 34 | **0** | **0** |
| B | Springtide (Unwin)—failure due to bad germination 1954-55 | — | 162 | — | — | — | 0 |
| B | Wrench's Queen of Market ... ... | 229 | 120 | 87 | 19 | **0** | **0** |
| BB | Advance ... ... | **257** | 154 | 107 | **9** | 1 | 0 |
| BB | Durham Early ... | 248 | **222** | 105 | 15 | **0** | **0** |
| BB | Sleaford Market ... | 225 | 158 | 95 | **7** | **0** | **0** |
| C | Emperor (Webb) ... | **250** | 172 | 114 | 13 | 2 | 1 |
| C | Milecross Marrow ... | 186 | **193** | 70 | **8** | 1 | 0 |
| C | Tender and True ... | 236 | 119 | 103 | **7** | **0** | **0** |
| D | Early Paragon ... | 240 | **199** | 111 | 25 | 1 | 0 |
| D | First Early ... ... | 165 | **222** | 57 | 21 | **0** | **0** |
| E | Carrington Early Market | **262** | **191** | 118 | 27 | 3 | 0 |
| E | Early Giant ... ... | **273** | **215** | **135** | 13 | **0** | 1 |
| E | Early Wonder (Finney) | 238 | **237** | 108 | 23 | 1 | 0 |
| E | Early Wonder (Fogwill) | 228 | 165 | 107 | 19 | **0** | **0** |
| E | Foremost ... ... | **299** | 164 | **138** | **12** | **0** | **0** |
| E | Knowefield Early ... | 202 | 148 | 97 | 21 | 0 | 1 |
| E | Market Favourite ... | **275** | **190** | 111 | 18 | **0** | **0** |
| E | Offenham Hardy Strain | **257** | 170 | **130** | 25 | **0** | **0** |
| E | Spring Glory ... ... | 244 | **187** | 102 | 22 | 1 | 0 |
| F | Beefheart ... ... | **271** | 101 | **156** | 21 | 1 | 0 |
| F | Earliest of All ... ... | 233 | 116 | 84 | 32 | 1 | 0 |
| F | Flower of Spring—not grown 1953-54 ... | **255** | — | **134** | 14 | 0 | — |
| F | Heartwell ... ... | 238 | 107 | **122** | 25 | 1 | 0 |
| F | Imperial ... ... | 225 | 119 | 104 | **4** | **0** | **0** |
| F | Spring ... ... ... | **252** | 159 | **131** | 14 | 3 | 1 |
| | Key to heavy type ... | 250 or above | 180 or above | 120 or above | 12 or less | no bolting in either year | |

*For suppliers see classified list.

TABLE II (*continued*)

*Spring cabbage varieties. Yield and performance as 'hearted cabbage' (normal sowing). 1954-55.*

| Group | Name* | Marketable yield 100's lb. per acre | | Peak cut 100's lb. per acre 1954-55 | % plants never fit to cut (includes bolters) 1954-55 | % bolting | |
|---|---|---|---|---|---|---|---|
| | | 1954-55 | 1953-54 | | | in 1954-55 | in 1953-54 |
| G | Ideal Early ... ... | 169 | 178 | 71 | 40 | **0** | **0** |
| G | Little Pixie ... ... | 172 | **180** | 88 | 27 | **0** | **0** |
| G | May Day ... ... | 151 | **244** | 76 | 46 | 1 | 1 |
| G | Number One ... ... | **305** | 96 | **145** | **2** | **0** | **0** |
| H | Criterion ... ... | **251** | 170 | 102 | **8** | 1 | 0 |
| H | Early Gem ... ... | 201 | 154 | 102 | 20 | **0** | **0** |
| H | Early Market 218 ... | **282** | **204** | **132** | **9** | **0** | **0** |
| H | Early Spalding ... | **270** | 174 | **132** | 19 | **0** | **0** |
| H | Excelsior ... ... | 203 | **180** | 94 | 26 | 2 | 0 |
| H | Leader ... ... ... | 240 | 154 | 77 | 14 | **0** | **0** |
| H | Liverpool Market ... | 169 | **183** | 87 | 46 | **0** | **0** |
| H | Newcastle Market ... | 163 | 159 | 76 | 42 | **0** | **0** |
| H | Spalding Market ... | 149 | **193** | 99 | 26 | 2 | 0 |
| H | Twelve Weeks ... ... | 203 | 167 | 87 | 33 | 1 | 0 |
| J | Cooper's First ... ... | 223 | **231** | 87 | 34 | 3 | 2 |
| J | Early Invincible ... | 196 | 151 | 97 | 26 | 1 | 0 |
| J | Emperor (Toogood) ... | **254** | **203** | 103 | 17 | **0** | **0** |
| K | Best of All ... ... | 177 | 122 | 79 | 45 | 4 | 1 |
| K | Dwarf ... ... ... | **305** | 165 | **145** | 14 | **0** | **0** |
| K | Early ... ... ... | **269** | 151 | 111 | **3** | **0** | **0** |
| K | Exhibition ... ... | 246 | 122 | 113 | 15 | **0** | **0** |
| K | First and Best ... ... | 211 | 136 | 102 | 25 | 2 | 0 |
| K | New Leader ... ... | 152 | **193** | 93 | 48 | 14 | 1 |
| K | Springtide ... ... | 198 | 141 | 93 | 17 | 1 | 0 |
| L | Coconut ... ... | **271** | 151 | **162** | **9** | 1 | 0 |
| L | Favourite ... ... | 204 | 125 | **129** | 13 | **0** | **0** |
| M | Early McEwan ... | 179 | 138 | 73 | 32 | **0** | **0** |
| M | Early Triumph ... | 232 | **210** | 102 | 20 | 0 | 1 |
| N | Précoce des Marchés ... | 246 | **196** | **142** | 15 | 2 | 3 |
| N | Très hâtif d'Etampes ... | 140 | **231** | 97 | 36 | 2 | 10 |
| O | Eastham ... ... | 39 | 70 | 25 | 75 | 10 | 2 |
| O | Improved Bullock Heart | 81 | **215** | 56 | 52 | 11 | 10 |
| P | Bacalan Gros ... ... | 5 | 31 | 5 | 80 | 8 | 2 |
| P | Bacalan hâtif ... | 27 | 90 | 30 | 85 | 6 | 2 |
| P | Chou de Chavannes ... | **351** | **270** | **169** | **12** | 5 | 2 |
| Q | Erstling Hunderup ... | 126 | 132 | 69 | 52 | 36 | 10 |
| R | Cotswold Queen ... | 197 | 167 | **124** | 13 | 0 | 2 |
| R | Erstling ... ... | 100 | 139 | 67 | 50 | 49 | 50 |
| R | Nonpareil (Hurst) ... | 162 | 171 | 104 | 29 | 6 | 2 |
| | Key to heavy type ... | 250 or above | 180 or above | 120 or above | 12 or less | no bolting in either year | |

*For suppliers see classified list.

The percentage of premature bolting was much lower for all varieties with 'normal' sowing than with 'early' sowing. Thus two weeks difference in sowing date was critical with regard to bolting. This suggests that in selecting for non-bolting characteristics, sowing somewhat earlier than the correct date for that variety should form a useful method of detecting latent susceptibility to bolting.

The percentage of diseased heads, caused mainly by *Botrytis* following frost damage, has not been included in Table II since it was low and relatively consistent for all varieties. The amount varied from nil to three per cent, most varieties having about 1.5 per cent. Colour and quality differences were also much less marked in the hearted cabbage than in the 'spring greens' crops.

Table III gives the results of an Analysis of Variance which was carried out on data from the 1954-55 trial.

TABLE III

| | Varieties did not differ significantly from one another in :— | Some varieties differed significantly from others in :— |
|---|---|---|
| Early sowing | Number of missing plants<br>Number of off-types | Number of premature bolters<br>Total marketable yield<br>Mean head weight |
| Normal sowing | Number of missing plants<br>Number never fit to cut | Total marketable yield<br>Number of unmarketable hearts (i.e. diseased)<br>Mean heart weight |

The percentage of bolting in most varieties when sown at the normal time was so low as to be unimportant and hence the data were not analysed statistically.

The analysis of variance showed also that the classification groups differed significantly from one another in the mean head and heart weights from the first and second sowings respectively, and in the total yields from both sowing dates. In addition to these differences between groups there was also a considerable amount of variation within groups. Significant differences between groups are to be expected in the mean heart weight since it is generally correlated with plant size, which was a character used in classification. Mean heart weights are given in the section on classification. No significant differences were found between the classification groups with respect to the other characters considered in the analysis. Tests of varietal differences for any particular character were made by means of the 'New Multiple Range Test' suggested by Duncan (1). The varieties are arranged in order of merit for that character and, taking any variety on the ranked scale, it is possible to establish the first variety (up or down the scale) which is significantly different from the one chosen. This has been done for the top ranking variety for each character—see Tables IV and V. The varieties lying between the top and the point of significance may be regarded as being comparable with the top variety.

Table IV shows that many of the varieties giving the best yield were also those with no premature bolting. Thus lack of bolting seems to be directly connected with cropping capacity in early-sown material. On the other hand, Table V shows that none of the varieties with the best yield is free from disease. Thus, as might be expected, disease resistance by itself does not ensure that a variety will be high yielding. The nine varieties with no disease were all of rather extreme types of poorer cropping ability. Seven of these had an elliptical heart and crisp rather shiny leaves of a yellow-green colour. These varieties were prone to bolting and were late hearting. The other two varieties were rather late and coarse. It seems that a small percentage of diseased heads must be tolerated in the rather soft, tender and early growing type favoured particularly by the southern British market until such time as disease resistance is introduced into them by breeding methods.

The highest yielding variety as a hearted cabbage, Chou de Chavannes, is foreign and of an unusual type—rather dark blue-green, with a curly leaf. It is also rather late in reaching maturity and since several British varieties of much earlier maturity have a comparable yield, it is unlikely that this foreign variety will prove to be worth consideration commercially.

Many growers require a variety which can be sown relatively early, and either cleared for 'greens' if the market is good, or thinned and left for hearted cabbage if the 'greens' market is poor. It can be seen from Tables IV and V that only one variety, Early Market 218, is among the best yielders both as 'greens' and as 'cabbage'. There are, however, a further two, Early and Early Spalding, which are among the best yielders as 'greens' and among the second best yielders as hearted cabbage. Unfortunately, all these three varieties which show promise for dual purpose use are of the rather large, coarse, and loosely hearted type which is not favoured in southern markets. This may be inevitable in a dual purpose variety, since the performance as 'spring greens' depends on an ability to produce a large quantity of leaf at the beginning of the season. Nevertheless, a breeding programme with the object of combining desirable characters in a dual purpose variety is now in progress, and the information reported here has provided a valuable basis for this work.

TABLE IV

*Best varieties at Wellesbourne as 'spring greens' (early sowing)*

1954-55

| Best yielders | | | | Free from bolting | | |
|---|---|---|---|---|---|---|
| Group | Name | Supplier | Yield 100's lb. per acre | Group | Name | Supplier |
| †B | Rous Lench | Speed | 167 | †B | Rous Lench | Speed |
| †B | Severn Stoke | Stokes (*Evesham*) | 167 | †B | Severn Stoke | Stokes |
| G | Ideal Early | Yates | 167 | B | Early Kent | Harrison (*Leicester*) |
| *†K | Early | Woodward | 162 | †K | Early | Woodwards |
| †BB | Durham Early | Clucas | 146 | †BB | Durham Early | Clucas |
| *†H | Early Market 218 | Clucas | 146 | †H | Early Market 218 | Clucas |
| †D | Early Paragon | Speed | 142 | †D | Early Paragon | Speed |
| E | Early Giant | Sutton | 141 | H | Liverpool Market | Finney |
| E | Early Wonder | Finney | 139 | H | Newcastle Market | Finney |
| *†H | Early Spalding | Elsom | 139 | †H | Early Spalding | Elsom |
| B | Myatt's Early Offenham | Tozer | 135 | M | Early McEwan | Scarlett |
| K | First and Best | Hurst | 135 | E | Offenham Hardy Strain | Watkins & Simpson |
| G | May Day | Dickson | 134 | | | |

*Varieties with high yield at both sowing dates.

†Free from bolting and also in 'best yield' group at early sowing.

TABLE V

*Best varieties at Wellesbourne as 'hearted cabbage'*
*(normal sowing)*
1954-55

| Best yielders | | | | Free from disease | | |
|---|---|---|---|---|---|---|
| Group | Name | Supplier | Yield 100's lb. per acre | Group | Name | Supplier |
| P | Chou de Chavannes | Müller | 350 | R | Cotswold Queen | Hurst |
| K | Dwarf | Barr | 306 | R | Erstling | Dippe |
| G | Number One | Finney | 306 | | | |
| E | Foremost | Unwin | 299 | N | Précoce des Marchés | Vilmorin |
| B | Early Market | Hurst | 297 | | | |
| *H | Early Market 218 | Clucas | 282 | | | |
| B | Early Kent | Harrison (*Leicester*) | 280 | N | Très hâtif d'Etampes | Vilmorin |
| Second best yielders. Varieties below this line are significantly poorer than Chou de Chavannes. | | | | M | Early Triumph | Sharpe |
| | | | | M | Early McEwan | Scarlett |
| E | Market Favourite | Finney | 275 | | | |
| F | Beefheart | Carter | 271 | K | Best of All | Fogwill |
| *H | Early Spalding | Elsom | 271 | | | |
| L | Coconut | Sharpe | 271 | K | New Leader | Webb |
| *K | Early | Woodward | 269 | | | |
| B | Early Feltham | Watkins & Simpson | 269 | O | Improved Bullock Heart | Clucas |

*Varieties with high yield at both sowing dates.

## SUMMARY

One hundred varieties of spring cabbage and similar foreign cabbages have been grown at the N.V.R.S., Wellesbourne, and have been placed into 17 groups based on differences in maturity period, heart shape and other morphological characters. In addition there was a class containing varieties unsuitable for summer and autumn sowing. Details are given of the varieties within these groups and an alphabetical index of varieties is provided as an appendix.

Varieties have been grown in trials, with two sowing dates and data and observations on yield and performance are given.

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## REFERENCE

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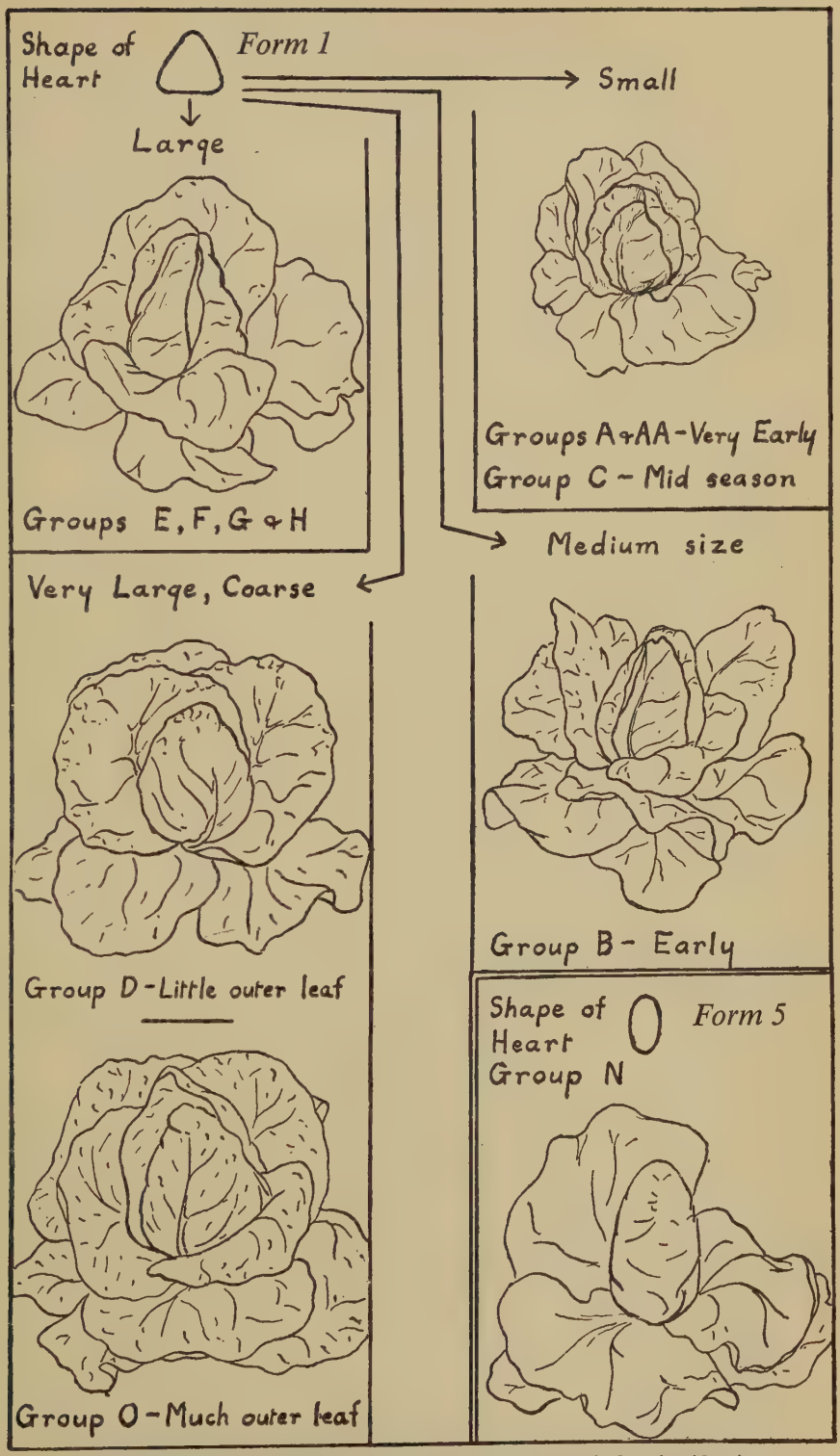
## APPENDIX TABLE I

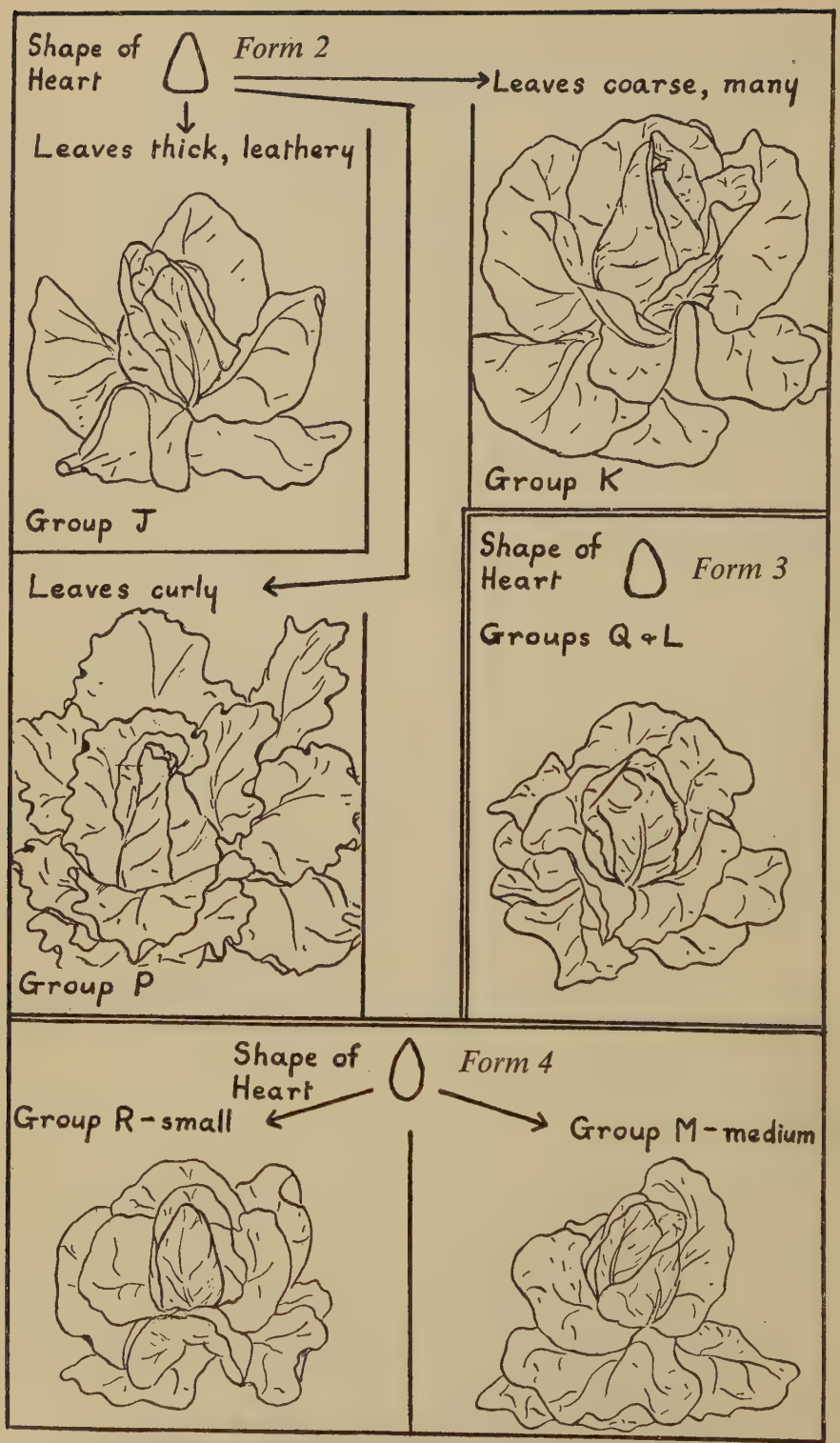
| *Variety.* | *Class* (*Roman numeral*) *Form* (*Arabic numeral*) *Group* (*Initial*) | | |
|---|---|---|---|
| Advance | II | 1 | BB |
| Bacalan Gros | IV | 2 | P |
| Bacalan hâtif | IV | 2 | P |
| Beefheart | III | 1 | F |
| Best of All (Fogwill's) | III | 2 | K |
| Carrington Early Market | III | 1 | E |
| Charleston Wakefield | V | | |
| Chou de Chavannes | IV | 2 | P |
| Chou Express | V | | |
| Coconut | III | 3 | L |
| Coeur de Boeuf de Jersey | V | | |
| Coeur de Boeuf Gros | V | | |
| Colewort | V | | |
| Conqueror (Pearson's) | I | 1 | A |
| Cooper's First | III | 2 | J |
| Cotswold Queen | IV | 4 | R |
| Covent Garden (Fogwill's) | II | 1 | B |
| Criterion (Barr's) | III | 1 | H |
| Durham Early (Cluseed) | II | 1 | BB |
| Dwarf (Barr's) | III | 2 | K |
| Earliest of All | III | 1 | F |
| Early (Woodwards') | III | 2 | K |
| Early Feltham | II | 1 | B |
| Early Gem | III | 1 | H |
| Early Giant | III | 1 | E |
| Early Invincible | III | 2 | J |
| Early Kent (Harrison's) | II | 1 | B |
| Early Market | II | 1 | B |
| Early Market 218 | III | 1 | H |
| Early McEwan | III | 4 | M |
| Early Paragon (Speed's) | III | 1 | D |
| Early Perfection | II | 1 | B |
| Early Queen (E. W. King's) | II | 1 | B |
| Early Spalding (Elsom's) | III | 1 | H |
| Early Triumph (Sharpe's) | III | 4 | M |
| Early Wonder (Finney's) | III | 1 | E |
| Early Wonder (Fogwill's) | III | 1 | E |
| East Ham | IV | 1 | O |
| Emperor (Toogood's) | III | 2 | J |
| Emperor (Webb's) | III | 1 | C |
| Enfield Market | V | | |
| Erstling | IV | 4 | R |
| Erstling Hunderup | IV | 3 | Q |
| Excelsior | III | 1 | H |
| Exhibition (E. W. King's) | III | 2 | K |
| Express | V | | |
| Favourite (Webb's) | III | 3 | L |
| First and Best | III | 2 | K |
| First Crop (D. T. Brown's) | I | 1 | A |
| First Early (E. W. King's) | III | 1 | D |
| First of All (Webb's) | I | 1 | AA |
| Flower of Spring (Sutton's) | III | 1 | F |

## APPENDIX TABLE I (*continued*)

| *Variety* | *Class* (*Roman numeral*) | *Form* (*Arabic numeral*) | *Group* (*Initial*) |
|---|---|---|---|
| Foremost (Fogwill's) | I | 1 | AA |
| Foremost (Unwin's) | III | 1 | E |
| Harbinger | I | 1 | AA |
| Heartwell (Carter) | III | 1 | F |
| Ideal Early (Yates') | III | 1 | G |
| Imperial (Webb's) | III | 1 | F |
| Improved Bullock Heart | IV | 1 | O |
| Jersey Wakefield | V | | |
| Knowefield Early | III | 1 | E |
| Leader (Cullen) | III | 1 | H |
| Little Pixie | III | 1 | G |
| Liverpool Market (Selected) | III | 1 | H |
| Maincrop (Ryder's) | I | 1 | AA |
| Market Favourite (Finney's) | III | 1 | E |
| May Day | III | 1 | G |
| Milecross Marrow | III | 1 | C |
| Myatt's Early Offenham | II | 1 | B |
| Myatt's Early Offenham (Select) | II | 1 | B |
| Nantais hâtif (Joanet) | V | | |
| Newcastle Market (Finney's) | III | 1 | H |
| New Leader (Webb's) | III | 2 | K |
| Nonesuch (Toogood's) | II | 1 | B |
| Nonpareil (Hurst's) | IV | 4 | R |
| Number One | III | 1 | G |
| Offenham Hardy Strain | III | 1 | E |
| Perfection (Ryder's) | V | | |
| Pommé plat de Paris | V | | |
| Précoce des Marchés | III | 5 | N |
| Queen of Spring (King's) | II | 1 | B |
| Rous Lench | II | 1 | B |
| Severn Stoke | II | 1 | B |
| Sleaford Market (Sharpe's) | II | 1 | BB |
| Southampton Wonder (Toogood's) | I | 1 | AA |
| Spalding Market (Elsom's) | III | 1 | H |
| Spring (Bees') | III | 1 | F |
| Spring Glory (D. T. Brown's) | III | 1 | E |
| Springtide | III | 2 | K |
| Springtide | II | 1 | B |
| Superfine | I | 1 | AA |
| Tender and True (Clibran's) | III | 1 | C |
| Très hâtif d'Etampes | III | 5 | N |
| Très précoce à grosse pommé | V | | |
| Twelve Weeks (Ryder's) | III | 1 | H |
| Wakefield | V | | |
| Wheeler's Imperial | I | 1 | AA |
| Winnigstadt | V | | |
| Witham Wonder | I | 1 | A |
| Wrench's Queen of the Market | II | 1 | B |




Diagrammatic representation of characters used as a basis for classification of spring cabbage into groups. Groups A to H, N and O.




Diagrammatic representation of characters used as a basis for classification of spring cabbage into groups. Groups J to M and P to R.

# CHEMISTRY REPORT

By F. HAWORTH

## Field experiments

The three long-term experiments laid down in the autumn of 1953 have now had two years cropping. Whilst it is too early to draw definite conclusions from the results obtained so far, certain interesting trends are evident. In considering the comments which follow, it should be remembered that the growing season of 1954 was excessively wet whilst that of 1955 was unusually dry. In 1955 the supply of irrigation water, which is restricted to a daily maximum, was inadequate to meet all requirements and the small amount of water available for these experiments was used to ensure germination of sown crops and establishment of transplanted crops.

## Cultivation experiment

The deep cultivation treatments were significantly better than the shallow treatments for peas, Brussels sprouts and spring cabbage in 1954 but the effect was the opposite for leeks. In 1955 the different cultivation treatments did not produce significantly different yields of peas.

It would appear that for all crops in this experiment there were no yield differences which could be attributed to differences in the time of application of phosphatic and potassic fertilisers. The sensitivity of leeks and Brussels sprouts to shortage of phosphate and potash on those plots receiving only nitrogenous manures was rather surprising when compared with peas which, in 1954, were not affected by the omission of phosphate and potash from the manurial mixture, and in 1955 were affected to a much smaller extent than the crops of leeks and Brussels sprouts.

## Nitrogen experiment

The crop rotation, described in the Annual Report for 1954, has been amended as from 1955 to include summer cabbage instead of carrots as the fourth crop of the rotation. This change has been made since the levels of nitrogen used in the experiment are fairly high and are such that even the lowest level is sufficient to give a good yield of carrots. Summer cabbage, on the other hand, appears to have a much higher nitrogen requirement and would be expected to give responses to the higher nitrogen levels. The most striking result from this experiment so far is the beneficial effect of FYM which, although expected, was perhaps greater (20 to 30 per cent) in all crops in both wet and dry years than would be anticipated. The main feature of the range of nitrogen treatments has been the superior effect of a given amount of inorganic nitrogen over the same quantity of nitrogen applied in the form of hoof and horn meal. This effect is most marked in the case of rapidly growing crops and would seem to indicate that the rate of liberation of nitrogen from the coarser particles in hoof and horn meal is too slow to provide an adequate supply of available nitrogen. Another interesting effect common to all crops in the rotation is that the yields obtained from treatments where the nitrogen (inorganic) is applied in one dose to the seed- or plant-bed are in no case inferior to those obtained from plots which have had the same, or an even greater, total amount of nitrogen but which have received it in four dressings.

During the year, several small non-replicated experiments were carried out with various fertiliser materials. None of the mixtures tried out was superior to a standard inorganic fertiliser mixture.

## Soils

The soil samples taken from all plots of the three long-term field experiments in 1953 have been analysed, and the results indicate an unusual degree of uniformity of the soil of the experimental area in mechanical composition and nutritional status. In only one block of the nitrogen experiment was there any wide variation from the

mean figures given in Table I and this variation was probably due to residues from stacks and clamps which are known to have occupied this site in the past. The variation does not appear to have affected the experiment.

TABLE I

*Soils from plots of long-term experiments*

| | | Mean of 352 samples | |
|---|---|---|---|
| | | 0–6 inches | 6–12 inches |
| Coarse sand .. .. | % | 52.0 | 51.9 |
| Fine sand .. .. .. | % | 25.3 | 24.7 |
| Silt .. .. .. | % | 8.4 | 8.7 |
| Clay .. .. .. | % | 11.8 | 12.0 |
| O.M. .. .. .. | % | 1.01 | 0.96 |
| *p*H glass electrode .. .. | | 6.4 | 6.3 |
| Available $K^+$ p.p.m. .. .. | | 57 | 49 |
| Available P p.p.m. .. .. | | 18 | 16 |
| Total N .. .. .. | % | 0.103 | 0.097 |

The *p*H status of all the Station's land is being systematically investigated on a 22 yard square grid basis. The *p*H values are irregular and hence the necessity for this very close sampling with its consequent large number of samples. However, once the *p*H is adjusted to approximate neutrality, a much smaller number of samples should suffice in future when deciding on the amount of lime needed by the soil in any particular field.

**Soil survey**

The detailed soil survey of the Station which was started in late 1953 has been completed. A soil map has been drawn and colour photographs have been taken of typical profiles. Soil samples from these profiles have been analysed.

Thanks are due to the Director of the Soil Survey of England Wales and to other members of his staff for valuable advice during the course of this survey.

**Plants**

A small chromatography laboratory was set up in July 1955 and the task of assembling the necessary equipment was begun. During the summer, samples of summer cabbage and of red beet were taken at frequent intervals from the long-term field experiments and preserved by freezing. The analysis of the inorganic and organic constituents will be undertaken during the winter.

Work is proceeding in an attempt to isolate from rhubarb sap a factor which appears to have an inhibitory effect on tobacco mosaic virus.

# IRRIGATION REPORT

By E. J. WINTER

In previous years, attention was concentrated on the development of apparatus and techniques for use in irrigation experiments. During 1955, these techniques were used in a number of experiments covering a wide range of vegetable crops, and some of the results are described below.

## EXPERIMENTS ON THE IRRIGATION OF CAULIFLOWERS (P. J. Salter)

An experiment was designed to measure the effect of three different continuous soil moisture regimes on the growth, yield and quality of Finney's 110 early cauliflower. The pot-grown plants were set in the field on 6th April. Whenever 25 per cent, 50 per cent and 75 per cent of the total water available in the root zone had been removed by evaporation and transpiration, the soil was restored to field capacity by irrigation. The regimes were controlled by means of regular gravimetric determinations of the moisture content of soil samples. In spite of continuous wet weather during the growth of this crop, the regimes were successfully maintained by using the plot shelters previously described (1).

Measurements were made of fresh weight, leaf area, curd weight, quality and earliness. For none of these characters did differences exceed 3.3 per cent between plants grown under the three treatments. These differences were not statistically significant (P=0.05). Tasting tests on cooked curds revealed that those from plants grown under the dry regime were slightly stronger in flavour than those from the wetter regimes.

Failure to obtain response to irrigation in this crop which is commonly irrigated may have resulted from a number of causes. The most likely reason was that the soil was unusually deep and fertile, and hence the roots of the plants may have been able to extend downwards in search of water as fast as they depleted the upper soil layers of available water. In support of this, excavations showed that the roots of plants grown in the dry regime extended deeper than those grown in the wetter regimes.

In a second experiment, Sutton's Novo autumn cauliflowers, planted out on 8th July, were subjected to three different continuous regimes, as follows :

*Treatment A.* The soil was restored to field capacity every day by adding the amount of water evaporated and transpired the previous day.

*Treatment B.* Sufficient water was added to restore the soil to field capacity whenever the water available in the root zone had been depleted by 50 per cent.

*Treatment C.* Sufficient water was added to restore the soil to field capacity whenever the whole of the water available in the root zone had been removed, i.e., the soil was allowed to dry to the theoretical wilting point.

In Treatment A the regime was controlled by daily calculation of potential evapotranspiration from meteorological data, using a method based on that of Penman (2). In Treatments B and C the regimes were controlled by means of gravimetric determinations of the moisture content of soil samples.

The growth rate, as measured by increase in mean leaf area, of plants in Treatment C up to the time of the first irrigation, was significantly less than that of plants under the other treatments. Immediately after the first irrigation, however, the growth rate of the plants under Treatment C became greater than that of the plants under Treatment A. Nevertheless, at the time of harvest, the Treatment C plants were still significantly smaller in leaf area than the plants grown under the other two regimes.

One and the same person judged when each curd was mature for cutting. Most of the crop was cleared from all plots under Treatments A and B (wet and medium regime) before those under Treatment C (dry regime) began to mature. Eventually,

bad weather and lateness of the crop made it necessary to clear the plots under Treatment C in a single cutting and only a very small yield was obtained which consisted entirely of unsaleable curds. The difference between yields from Treatments A and B did not exceed 9.5 per cent and was not statistically significant (P=0.05).

## EXPERIMENTS ON THE IRRIGATION OF TURNIPS (G. Stanhill)

Experiments were carried out using the turnip variety White Milan, and the results obtained were in general agreement with those previously reported (3). In one experiment, seeds were sown on 15th May and again at intervals of one week until 3rd July. Using the crop from each sowing, the effects of a three-weeks dry period were compared with those of a three-weeks period at field capacity, at eight different growth stages of the crop. At all times other than the periods mentioned, the plots were not sheltered from rain, but received natural rainfall supplemented with sufficient irrigation to ensure that the soil moisture content remained at a high level.

The results in Table I show that slightly better crops resulted from a dry period imposed at the stage between the expansion of the cotyledons and the unfolding of the fourth true leaf. The three-weeks period just before the harvest appeared to be a critical one for moisture supply to the crop because during this time dryness did most harm and wetness gave most benefit. The flavour and texture of the roots was not affected by water treatments applied more than four weeks before harvest. The results of these experiments substantiate those obtained in previous years, and hence it appears that in order to produce the maximum yield of mild-flavoured turnips, the crop should have a plentiful supply of water during the three weeks before harvest. During the period between establishment and the beginning of root swelling, however, the maintenance of high soil moisture content is apparently not beneficial.

TABLE I

*Yield from turnips which received a three-weeks period at field capacity, expressed as a percentage of the yield from turnips which received a three-weeks dry period* (1955)

| | Stage of growth at time of treatment | | |
|---|---|---|---|
| | From sowing until expansion of cotyledons | From expansion of cotyledons until unfolding of fourth leaf | From unfolding of fourth leaf until harvest |
| Mean fresh weight of roots | 112.1 | 95.8 | 134.8 |
| Mean fresh weight of foliage .. .. | 123.6 | 97.3 | 112.6 |
| Root weight expressed as a percentage of weight of foliage .. .. | 97.1 | 99.2 | 106.8 |

## THE EFFECTS OF DIFFERENT SUSTAINED IRRIGATION TREATMENTS ON VARIOUS VEGETABLE CROPS (E. J. Winter)

The object of this experiment was to examine the gross effects of continuous dry, medium and wet regimes on a number of vegetable crops other than those cultivated for their leaves.

The plots were not sheltered from rain, and during the early stages of growth, showery weather kept the soil in all plots almost continually at field capacity. About half-way through the life of the plants, however, the weather changed and it became possible to maintain the desired regimes until harvest.

The treatments were as follows :—

*Dry regime :* No water was added. By the time harvesting was begun the soil moisture content of the plots under this treatment had fallen to about 11 per cent.

*Medium regime :* Sufficient water was added to restore the soil to field capacity whenever its moisture content had fallen to 15 per cent, i.e., when about half the available water had been used.

*Wet regime :* Sufficient water was added to restore the soil to field capacity every three days.

Wet and dry weight measurements of soil samples were used in determining soil moisture content.

Some of the results are shown in Table II. In general, the weight of marketable produce obtained from plots maintained at field capacity was not significantly different from that yielded by plots kept under the medium regime, but in most cases both were significantly greater than that obtained from the dry regime.

Red beet was exceptional in that the quantity of leaves produced was unaffected by the different regimes.

With carrots, almost twice as much foliage was produced in the wet and medium regimes as in the dry regime. In the dry regime the foliage was dark in colour. The differences in the yield of roots, however, were less than might have been expected from the differences in quantity of foliage.

With peas, the dry regime appeared to give earlier maturity than the wet regime but the figures for yield of saleable produce were inconclusive.

The figures for broad beans showed a similar trend although, with this crop, moderate over-ripeness could be tolerated in the marketed produce and there was no need to discard any of the pods as being over-ripe.

Runner beans grown under the dry regime yielded less saleable produce and less leafy material than when grown under the other regimes, but the quantity of immature produce did not differ in the different regimes. This is to be expected in a crop which continues to flower over a long period.

The foliage produced by the marrow plants was not weighed, but was observed to be greener and more extensive in the wet and medium regimes than in the dry one. The difference in yield of marrows produced by the three regimes, however, was comparatively small.

These results show that many crops tend to produce more leafy material when grown in a sustained wet regime than in a dry regime, but that this difference is not always associated with increased yield of saleable produce. There were effects on earliness in at least one crop, and differences in colour and texture of leaves may well have been accompanied by changes in quality of the edible parts of the plants.

## TABLE II

*Yield in pounds per yard of row of vegetables grown under different soil moisture regimes* (1955)

| Regime | Saleable produce | | | | | Leaves and stems | | | | | Immature produce | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wet | Medium | Dry | LSD | %se | Wet | Medium | Dry | LSD | %se | Wet | Medium | Dry | LSD | %se |
| Runner beans .. | 1.9 | 2.1 | 1.6 | 0.4 | 30.6 | 4.7 | 4.7 | 3.9 | 0.6 | 18.7 | 0.2 | 0.2 | 0.2 | 0.1 | 24.8 |
| Broad beans .. | 2.6 | 3.2 | 2.4 | 0.5 | 10.6 | 8.6 | 8.3 | 5.9 | 0.8 | 5.7 | 0.4 | 0.3 | 0.2 | 0.3 | 55.2 |
| Red beet .. .. | 1.9 | 2.0 | 2.1 | 0.3 | 22.1 | 3.0 | 2.7 | 2.9 | 0.4 | 18.1 | — | — | — | — | — |
| Carrots .. .. | 2.4 | 2.4 | 2.0 | 0.3 | 8.9 | 4.3 | 3.8 | 2.0 | 1.0 | 17.9 | — | — | — | — | — |
| Marrows (pounds per plant during whole season) .. | 28 | 20 | 26 | 10.6 | 22.1 | — | — | — | — | — | 5.0 | 11.0 | 5.0 | — | — |

LSD=Least significant difference (P=0.05)

%se=Standard error per plot as percentage of general mean.

## FURTHER STUDIES ON THE LOSS OF WATER FROM PLANT/SOIL SYSTEMS IN THE FIELD (G. Stanhill)

It has been previously reported (4) that the magnitude of the difference between the water loss from an open water surface estimated from meteorological observations (2) and the measured water-loss from an evaporation tank, varied according to the season of the year. Further observations confirmed that the size of the discrepancies varied inversely with the mean daily temperature, but it appeared unlikely that any one factor was the sole cause of the differences. A number of factors were investigated with a view to modifying the formulae so as to minimise the differences. These factors included the time of day at which sunshine occurred, the relationship between sunshine and solar radiation, and the temporary storage of heat in the soil, or in the water of the evaporation tank. In addition to their possible effect on evaporation these factors may directly influence the growth of plants, and it will be necessary to accumulate observations over a long period in order to elucidate their direct effects and interactions on evaporation, transpiration and plant growth. In connection with these studies, regular measurements of water loss from weighable monolith soil cores bearing grass crops have been added to the routine Crop Weather Station observations at Wellesbourne.

For research purposes it is necessary to estimate water consumption by a growing crop (i.e., transpiration from the plants plus evaporation from the soil) over short periods of time. A comparison of discrepancies between estimated and measured water losses over varying time intervals showed that the size and variance of the differences were similar for single days and for ten-day intervals. The improvement brought about by using monthly intervals was small and was complicated by the seasonal variation mentioned above. It was concluded, therefore, that for practical purposes, daily estimates of water loss made by Penman's methods were no less satisfactory than those made over longer periods.

Using data obtained from a turnip crop, an attempt was made to divide the total water loss into three components :—

A. Loss by evaporation from the soil surface.

B. Loss by evaporation from the plant surface, i.e., evaporation of rain or dew from the wet foliage.

C. Loss by transpiration.

Values for each of these components were obtained for three stages of the growth of the crop :—

*Stage* 1 From germination until there was a measurable amount of plant cover.

*Stage* 2 From stage 1 until the plants completely covered the ground.

*Stage* 3 From stage 2 until harvest.

The loss of water by evaporation from the soil surface was estimated using a previously established relationship between evaporation from soil surfaces and from water surfaces ; the loss by evaporation from the plant surfaces was calculated from measurements of the water-holding capacity of the foliage at different growth stages. Transpiration was estimated from measurements of evaporation from a water surface, using Penman's conversion factor of 0.8 (2). Table III shows the changes in relative loss of water brought about by each of the three components as the crop developed. Nearly half the total loss occurred during the last third of the life of the crop, i.e., when the plants were completely covering the ground.

Where possible, the estimated values were compared with values obtained by direct measurement. For example, special rain gauges were used to collect only that fraction of the rainfall which penetrated the plant canopy ; weighable soil cores were used to measure evaporation beneath the canopy and in the open, and representative soil samples were taken regularly for gravimetric determination of soil moisture content. Table IV shows that when the estimated values are expressed as percentages

of total water loss, they agree well with the results of the measurements. When expressed in inches, however, the estimated values are consistently lower than the measured values. The reason for this discrepancy has not yet been found.

TABLE III

*Estimated water loss from a turnip crop* (1955)

| | Each growth stage as percentage of total life of plants | Percentage water loss | | | Percentage of total water loss |
|---|---|---|---|---|---|
| | | Evaporation from soil | Evaporation from foliage | Transpiration | |
| Stage 1 Germination until plant cover was measurable .. | 38 | 100 | 0 | 0 | 21 |
| Stage 2 Until plant cover was complete .. | 25 | 51 | 2 | 45 | 28 |
| Stage 3 Until harvest .. | 36 | 0 | 3 | 97 | 51 |

TABLE IV

*Comparison between estimated and measured water loss from a turnip crop* (1955)

| | Evaporation from soil | Evaporation from foliage | Transpiration | Total water loss |
|---|---|---|---|---|
| Estimated water loss—inches .. | 2.84 | 0.18 | 5.06 | 8.08 |
| Measured water loss—inches .. | 3.74 | .33 | 6.71 | 10.18 |
| Estimated water loss as a percentage of total estimated water loss | 35 | 2 | 63 | 100 |
| Measured water loss as a percentage of total measured water loss | 31 | 3 | 66 | 100 |

## INSTRUMENTS FOR DETERMINING SOIL MOISTURE STATUS

**(E. J. Winter and G. Stanhill)**

The performances of twelve different types of electrical resistance blocks, including some on sale in this country and the U.S.A., were compared for one year in a weighable soil tank carrying a grass cover-crop. Both the nylon and the plaster blocks designed

and made at Wellesbourne compared favourably in most respects with the commercial types but, in general, the results indicated that the electrical resistance method for estimating soil moisture status cannot yet be recommended for use by growers in this country.

In a different approach to the problem of simplifying the determination of soil moisture status, an instrument is being developed which consists of a combined rain-gauge and evaporimeter (5). Several seasons' work will be required to calibrate the prototype, but it is hoped that this instrument will eventually enable a grower to deduce at any time the current soil moisture status of his soil, and hence to determine the maximum amount of irrigation water which he should apply.

## A FORCED VENTILATION SYSTEM FOR COOLING SMALL GLASSHOUSE COMPARTMENTS (E. J. Winter)

In sunny weather, small compartments of glasshouses such as those used for plant breeding, are subject to considerable temperature rise. This heating is difficult to control by normal methods of ventilation, and when ventilation is further restricted by insect-proofing, temperatures of the order of 130°F. may be reached.

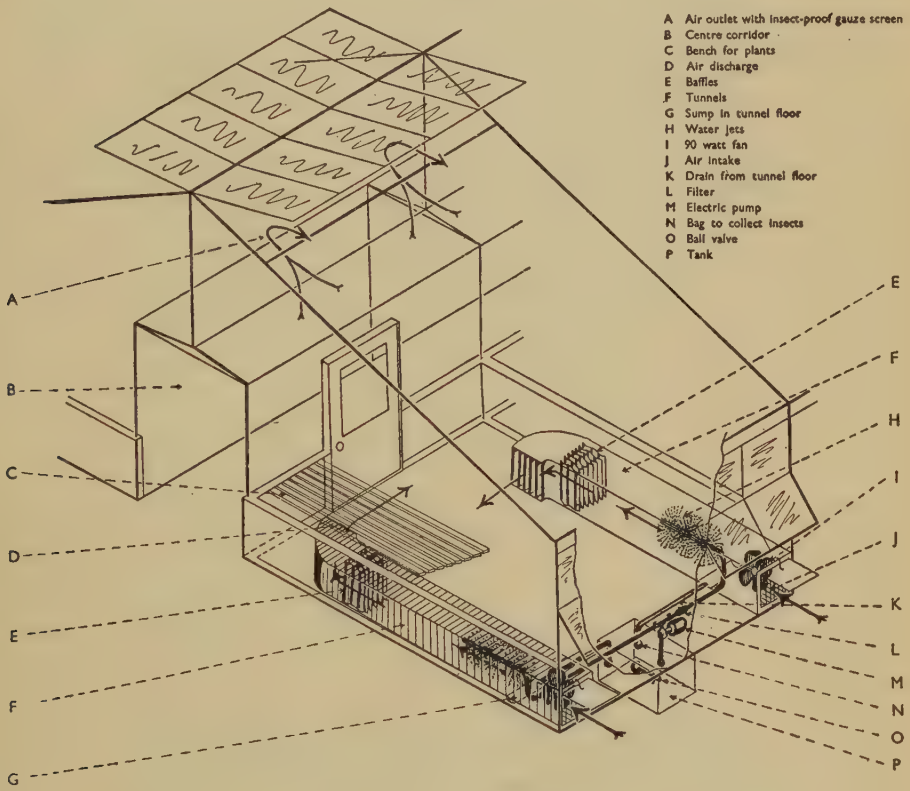



Fig. 1 shows equipment which has been designed for the forced ventilation of insect-proof compartments. Tests during the hot summer of 1955 showed that even in sustained bright sunshine the apparatus would maintain the inside temperature of a compartment of 1,300 cubic feet capacity at about 2°F. above the outside shade temperature. Outside air was forced through tunnels at a ventilation rate of 60-70 changes per hour in the compartment. In the tunnels, the air was freed from insects by dense water sprays instead of by the usual gauze screens. This enabled the size of

the fans to be considerably reduced. Furthermore, when the relative humidity outside was low, evaporation of some of the water cooled the incoming air so that the compartment temperature was two or three degrees below outside shade temperature. A manually operated valve enabled relative humidity within the compartment to be controlled at about 75 per cent, but it would be a simple matter to incorporate automatic control of humidity.

The floors of the tunnels were sloped towards the air intakes, so that any insects which were not killed by the water sprays were washed into the drainage sump from which the water circulating pump drew its supply. For test purposes, large numbers of various kinds of insects were introduced into the air intakes ; while the apparatus was working none of the insects could be found in the compartment.

Other glasshouse cooling systems were tested. Spraying water on to the glass roof of the compartment at the rate of 1,000 gallons per hour per 30 square feet had little effect on inside temperature. Maintaining a layer of mist one foot thick above the roof considerably reduced the inside temperature, but this system was impracticable because blown spray saturated the surrounding area.

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# ENTOMOLOGY REPORT

By D. W. WRIGHT

The work of the Entomology Section during 1954-55 was partly concerned with projects which had been under investigation for some time and partly with certain new projects. Among the latter were field and laboratory studies on the natural enemies of the cabbage root fly, investigations on the biology and control of the lettuce root aphid, and field and laboratory experiments on the control of carrot fly on parsnips.

## CABBAGE ROOT FLY (D. W. Wright and J. S. Buxton)

(a) *Control of cabbage root fly with plant dips containing insecticides*

A series of field experiments was carried out to determine the value of insecticidal root dips for the control of cabbage root fly. The roots and base of the stems of cabbage plants were dipped, before transplanting, into solutions containing aldrin, dieldrin or lindane. After harvesting, the cabbage roots were lifted and assessed for root fly damage. The most effective material was dieldrin, which gave an almost complete control at a concentration of 0.06 per cent. An indication of the relative effectiveness of the three insecticides as used in these experiments is shown in Table I. Aldrin and dieldrin were also used as emulsions and gave results similar to those obtained with the suspensions.

TABLE I

*Control of cabbage root fly by root dips*

*Primo cabbage*—1955

| Insecticide (used in suspension) | Concentration of toxicant in dip % | Plants damaged by root fly % |
|---|---|---|
| Aldrin .. .. .. | 0.04 | 57.5 |
| Aldrin .. .. .. | 0.08 | 20.0 |
| Dieldrin .. .. | 0.04 | 7.5 |
| Dieldrin .. .. | 0.08 | 0.0 |
| Lindane .. .. | 0.04 | 100.0 |
| Lindane .. .. | 0.08 | 87.5 |
| Control .. .. | — | 92.5 |

The lindane suspensions proved the least effective and dipping experiments over the past two years have shown that a dip concentration of 0.5 per cent gamma BHC is required to give a satisfactory control. At this concentration, however, phytotoxic effects are very liable to occur whereas dieldrin may be used effectively at much lower concentrations with little risk of damage.

Dipping, although much cheaper to carry out, usually gives a less complete root fly control than a drench treatment. In addition, if conditions for transplanting are not good, a growth check is liable to occur. Growth checks may occur even from dipping in water and result in crop harvest being delayed by several days.

(b) *Control of cabbage root fly in seed beds*

The damage caused by the cabbage root fly is not confined to the transplanted brassica crops and is often severe in the seed beds. The root systems of the seedlings are attacked and may be destroyed, but more frequently the damage is less severe and the plants, although stunted, remain alive. Until recently recommendations for the control of this insect in seed beds have been based on the use of 4 per cent calomel dust.

A replicated experiment was carried out on à cabbage seed-bed using various formulations of aldrin, dieldrin and lindane. Details of the treatments used and the results obtained are shown in Table II. The liquid and dust materials were in each case applied as a band along the rows when the seedlings were in the second to third true-leaf stages. The lindane seed dressing was applied before sowing, using paraffin as a sticker. When the plants were ready for transplanting a sample was taken from each plot and the damage caused by root fly was assessed.

TABLE II

*Control of cabbage root fly in seed-beds*

*Primo cabbage—Wellesbourne* 1955

| Insecticide | Concentration of toxicant % | Rate of application | Plants attacked % |
|---|---|---|---|
| Aldrin suspension .. | 0.06 | 1 gallon per 25 row yards | 4 |
| Aldrin dust .. .. | 1.25 | ½ lb. per 25 row yards | 11 |
| Dieldrin suspension .. | 0.03 | 1 gallon per 30 row yards | 0 |
| Lindane suspension .. | 0.02 | 1 gallon per 30 row yards | 2 |
| Lindane seed dressing .. | 75.00 | 1 ounce per 1 lb. seed | 4 |
| Control .. .. .. | — | — | 41 |

All three insecticides when used in suspension in water proved very effective as also did the lindane seed dressing. The latter treatment may therefore serve a dual purpose since it also gives substantial protection to young seedlings against flea beetles (*Phyllotreta* sp.).

To determine if the seed-bed treatments would give further protection against root fly, after transplanting, a sample of 40 plants from each plot was set out in the field. Some two months later, after the crop had been harvested, the root fly damage was again recorded. All the seed-bed treatments gave only a slight reduction in field attack with the exception of the dieldrin spray which gave a 58.2 per cent reduction in damage compared with that on the untreated plots. This level of protection cannot be regarded as adequate, especially in controlling heavy field infestations, and supplementary spray and dip treatments of the transplanted crop would appear to be necessary.

## NATURAL ENEMIES OF THE CABBAGE ROOT FLY
### (D. W. Wright, W. R. Howells and Dorothy D. Bowe)

The part played by predatory insects in reducing the natural populations of cabbage root fly has been studied in the laboratory and in the field. Feeding tests carried out under laboratory conditions showed that more than thirty species of beetles, chiefly belonging to the families Carabidae and Staphylinidae, would eat the eggs, larvae or pupae of the root fly, and two species of gamasid mites were also consistent feeders on the eggs or larvae. Certain species of carabid beetles were found to be the most voracious feeders ; one individual of *Bembidium lampros* (Herbst.) consumed 428 eggs, 159 first instar larvae and three third instar larvae over a period of six months. This species occurs in considerable numbers around brassica plants in the field as also does an allied beetle *Trechus obtusus* Fr., individuals of which have also consumed large numbers of eggs and larvae in the laboratory.

The larger carabid and staphylinid beetles appear to show a preference for the larger larvae and the pupae. One individual of the genus *Pterostichus* (Feronia) consumed 180 pupae and 23 third instar larvae of the root fly and a number of weevil larvae over a six month period.

Soil samples from field plots were taken throughout the year to ascertain the nature of the insect populations occurring in the soil around brassica plants as well as between the plants, and on fallow land nearby. By far the largest populations were found around the plants, the other sites supporting relatively small numbers of insects. In addition to determining the species concerned, the seasonal changes in populations in these environments were also studied.

A field experiment was carried out using DDT, aldrin and gamma BHC broadcast over the soil at the rates of 12, 2 and $\frac{3}{4}$ lb. per acre, respectively. These were rotavated into the top three inches of soil and cabbages were transplanted two weeks later. The cabbages on the plots which had received insecticides suffered much heavier root fly damage than did those on plots where no insecticide had been applied. Root and soil samples showed that there were far more larvae and pupae of the root fly on the treated plots than on those not treated. In addition, the samples also showed that the populations of Coleoptera in the soil were adversely affected for some three months after the application of the insecticides. Later, however, sampling indicated that their numbers had recovered to a nearly normal level. Since the laboratory tests have shown that many Coleoptera may be important natural enemies of the root fly, their reduction in numbers by the insecticides would have allowed a much heavier attack of root fly to occur on the treated plots. The concentration of the insecticides in the soil was, in each case, too low to be directly toxic to the root fly eggs and larvae.

Root fly egg counts on Primo cabbage and autumn cauliflowers showed that fewer eggs were laid in 1955 than in 1954, but that egg deposition continued longer, until the end of October, probably owing to the weather being much warmer than in the autumn of the previous year.

A technique for rearing cabbage root flies in the laboratory has been developed, thus providing a continuous supply of eggs and larvae for the testing of insects for predatory behaviour and for other biological work.

## CARROT FLY ON CARROTS (D. W. Wright)

Field experiments on the control of carrot fly on early, maincrop and late carrots were carried out on fen soil at Chatteris and on a medium loam at Wellesbourne. Seed treatments containing gamma BHC and dieldrin were used, both alone and in combination with dieldrin sprays applied to the growing crop. Attack by the first generation of the fly was slight at both centres, but heavy infestations of the second generation occurred. Seed treatments were only partially effective against these but when combined with three dieldrin sprays, applied at fortnightly intervals beginning in early August, a marked reduction in the attack occurred. All the seed and spray treatments were somewhat less effective than in 1954, possibly because the high summer temperatures caused a reduction in the persistence of the insecticides.

A tasting panel, consisting of 12 members of the research staff was set up. Much valuable information has been obtained on the effect of the various insecticidal treatments on carrot flavour. This work has been organised by Miss Bowe.

## CARROT FLY ON PARSNIPS (G. A. Wheatley and J. A. Hardman)

Field experiments have been begun with a view to developing a method for the control of the carrot fly (*Psila rosae* F.) attacking parsnips. Observations on the biology and life cycle of the pest were continued. In the Wellesbourne area the larvae of the second brood did not begin to damage the main root of the parsnip until the beginning of November 1954. This may have been due to the cold, wet conditions during the late summer and autumn but the matter is being further investigated.

Larvae and pupae were obtained from several localities. Morphological examination of the flies bred from this material demonstrated the extreme variability of the species but did not reveal any consistent difference between batches. As in the previous season, larvae obtained from parsnips, both in the field and in the laboratory, were again found to be smaller than those from carrots. Experiments have shown that this modification was apparently induced by the host plant.

Techniques for rearing the insect in the laboratory have been elaborated to enable the host relationships of the pest to be studied and also to obtain suitable material for insecticidal tests under laboratory conditions.

## LETTUCE ROOT APHID (J. A. Dunn)

The first season's work on the biology and control of lettuce root aphid coincided with an exceptionally heavy and widespread attack by this pest. The aphid overwinters in the egg stage on poplar. In the spring the eggs hatch and the young aphids develop within flask-shaped galls produced on the leaf stalks. In 1955, large numbers of winged aphids were formed in these galls and emerged at the end of June and throughout July. The weather over this period was very favourable for migration and very large numbers of the winged aphids came continuously into lettuce crops for a period of more than five weeks. Heavy infestations resulted and many crops of summer lettuce suffered severe damage. Drought helped further to aggravate the situation.

A field experiment was laid out with lettuce in which the aim was to prevent rather than to cure an infestation by the aphid. The insecticides, therefore, were applied to the crop at an early stage of plant growth and a certain number of seed dressings were also used. Germination and plant establishment tests showed that, whilst apparently tolerant to aldrin and endrin, lettuce seedlings were highly sensitive to damage by BHC. The maximum seed dressing that it was found possible to use—10 per cent by weight of the seed, of a 50 per cent gamma BHC dressing—failed to give any control of the aphid. A 0.45 per cent gamma BHC dust applied along the rows when the seedlings were in the first rough leaf stage and a 0.02 per cent gamma BHC spray applied along the rows both before and after singling were also ineffective. Soaking the seed for one hour in one per cent Schradan solution prior to sowing also gave no control. Very slight reductions in aphid numbers followed the use of aldrin as a seed dressing and of 0.1 per cent endrin spray applied along the rows prior to singling. A 0.8 per cent Schradan foliage spray applied at the rosette stage and a 0.1 per cent endrin spray applied along the rows after singling, gave improved but still inadequate control. However, up to the time when the first lettuces were ready for cutting, an endrin seed dressing (equal weights of seed and a dressing containing 50 per cent endrin) was found to have kept the aphid numbers to less than 20 per cent of those on the untreated plots. This degree of control must be regarded as considerable in view of the very prolonged and intense attack by root aphid to which lettuce were subjected.

A very important development in combating this pest was the discovery, among the summer lettuce grown by Mr. L. E. Watts at Wellesbourne, of varieties highly resistant to root aphid attack. Among the 'All the Year Round' type (Watts 1955) the variety White Favourite displayed what appeared to be total resistance to root

aphids. When sampled, none of the root stocks of this variety showed evidence of aphid attack whilst, at the same time, nearby susceptible varieties were found to be supporting lethal populations of root aphids in the region of 25,000 per plant. Other varieties which were found to be highly resistant to attack were : Midas ('White Boston' type) ; certain new unnamed American strains of Imperial ('Curly Crisp' type) ; Salad Bowl ('Leaf' type) ; and Reine de Glaces ('Curly Crisp' type). It is not yet known what causes these varieties to be resistant but it appears to be a heritable character, and the breeding of improved resistant varieties would seem to be a highly satisfactory method of dealing with the lettuce root aphid problem.

**INSECTICIDAL DUSTS (G. A. Wheatley)**

Further laboratory studies were carried out on DDT insecticidal dusts prepared by volatile solvent impregnation. The pea aphid was used to assess the relative efficiencies of deposits of dust particles of different size ranges. Several different types of measurements of deposits were studied in relation to toxicity in an attempt to formulate physical specifications which would not only define the deposit but also its potential toxicity. A measurement based on the surface area of the deposited particles was satisfactory in the case of one filler and its application to other fillers is being investigated.

**PEA MOTH (J. A. Dunn and G. A. Wheatley)**

Laboratory experiments have been continued on the effect of temperature on the rate of development of the overwintering larvae. Successive collections of material from the same source were made throughout the winter. The response to temperature changed with each successive collection. This may account for the previous observation that the time for development to the adult stage was different for material from different sources and this is being further investigated.

Continuous soil temperature records were obtained from field plots. The rate of accumulation of effective temperature was again most rapid in plots kept free of vegetation during the winter, spring and early summer, and was slowest on land bearing winter wheat. With spring wheat the rate of accumulation was at first the same as for the bare land but changed progressively as the cover of the crop increased and it finally approached that of the winter wheat plot. The time of emergence of the pea moth on these plots was directly related to the accumulation of effective temperature and was some two weeks later on the land planted with the cereal crop than on land kept bare of vegetation.

**Acknowledgments**

The members of the Section are grateful to all who have provided facilities for experiments and observations, and to those who have assisted with this work. In particular they wish to mention Mr. A. S. Rickwood, Chatteris and the Directors and staffs of the N.A.A.S. E.H.S. at Efford, Luddington and Stockbridge.

# PLANT PATHOLOGY REPORT

By W. G. KEYWORTH

During 1955 the work of the Pathology Section has been gradually expanded and the main lines of research fairly well defined. Reports on most of the work are given below.

## CROOK ROOT OF WATERCRESS (J. A. Tomlinson)

By the courtesy of a watercress grower several experiments were made in miniature watercress beds at Bere Regis, Dorset. The beds measure $22 \times 2\frac{1}{2}$ yards, lie adjacently and receive a common artesian water supply fed through independent sluices designed so that the water flowing into each bed can be measured. The flow of water to a bed is adjustable by increments of approximately 160 gallons per hour. The water in each bed is separated from the water in adjacent beds by concrete walls built on deep concrete footings laid below the level of the gravel floors of the beds.

Crook root developed in the beds after they had been planted with cuttings of 'brown' watercress. Assessments of the amount and distribution of crook root and of plant vigour demonstrated that both were similar to that in commercial-sized beds. Thus, the amount of infection was closely correlated with the distance of the plants from the water supply ; plants nearest the water inlet being the most vigorous and the least infected with crook root. The beds were used to investigate the pattern of crook root infection in two ways, (i) the effect of the loss of certain dissolved substances from the water and (ii) the effect of probable differences in zoospore concentration.

(i) *Dissolved substances.* Certain dissolved substances present in underground waters are known to fall rapidly in concentration when the water is brought into contact with the air (as occurs when artesian water flows into a watercress bed). Experiments were designed to test whether the loss of either carbon dioxide or iron compounds affected crook root incidence and plant growth. Free dissolved carbon dioxide, previously reported (4) as decreasing in concentration as the water flows down the bed, was also found to fall sharply in concentration in the experimental bed. Carbon dioxide was added to the inlet water in amounts sufficient to maintain a concentration at the outlet of the bed comparable with that at the source in untreated beds, but no measurable differences in plant weight or reduction in crook root were obtained from the treated bed.

Certain iron compounds are lost from artesian water by precipitation following oxidation. Tests of the addition to the inlet water of solutions of ferrous sulphate, ferrous sulphate with sodium metaphosphate*, and sodium metaphosphate alone were therefore made in three beds but no effects on the infection or the growth of plants as compared with the plants in untreated beds were observed. These tests are being continued.

(ii) *Zoospore concentration.* Experiments were performed to test whether the increase in infection from the top to the lower end of the beds was associated with the concentration of zoospores in the water. Water from the sluices, assumed to contain no zoospores, was passed through rubber tubing and injected into the middle of a bed where the plants were severely infected. After a few weeks a decrease in root infection and an increase in plant growth occurred on the plants growing immediately in front of the source of zoospore-free water. The effect was comparable with the streaks of vigorous watercress occasionally found to occur in commercial beds receiving supplementary supplies of water, as reported previously (8). When water from the same sluice was passed through a wooden trough filled with infected watercress plants, before being injected into the bed, no such effect was produced. This result suggests that the healthier condition of the plants receiving the fresh water was connected with the supply of zoospore-free water. The experiment does not, however, preclude the possibility that the second supply of water, which had passed through the trough containing cress plants, had thereby been altered in chemical composition. This possibility is now being tested.

*This compound is reported to prevent the oxidisation of solutions containing ferrous iron (7).

Following on the observation (9) that water from a local stream which inhibited infection usually had a high content of total bicarbonates, tests were made to determine the relationship between the quantity of calcium bicarbonate dissolved in distilled water and the incidence of infection. These experiments showed that calcium bicarbonate exercised a suppressing effect which increased with increasing concentrations up to 500 p.p.m. (=parts per million). A survey of the total bicarbonate content of more than a hundred artesian and spring waters supplying watercress beds in various counties was therefore made. It was found that with one exception the total bicarbonate content varied between 300 and 400 p.p.m. In addition several tests showed that the total bicarbonate content varied by only a few parts per million throughout the length of the beds so that the increase in infection down the beds was unlikely to be due to a loss of bicarbonates. The only bed with water containing a high total bicarbonate content (550 p.p.m.) was free from crook root although nearby beds with different water supplies were heavily infected. In view of these observations, tests are in progress to determine the effects of increasing the calcium bicarbonate content of the water supplying commercial beds.

## VIRUS DISEASES OF WATERCRESS (J. A. Tomlinson)

Examination of commercial crops continued to show the prevalence of virus-like symptoms in all but a few crops raised from seed. From the range of symptoms encountered it seemed possible that the plants were affected by a number of different viruses. Inoculation experiments with virus isolates from several widely scattered farms, however, showed them all to be capable of infecting and causing similar symptoms in several cruciferous plants. In addition, when the isolates were sap-inoculated into one watercress variety, all gave similar symptoms. It is possible, therefore, that the different field symptoms may all be caused by one virus, but this requires further test since on some indicator plants, e.g., *Chenopodium amaranticolor*, the various isolates produced dissimilar symptoms.

In addition to the hosts mentioned previously (10), transmissions were also obtained to wallflower, Chinese cabbage, a wild watercress (*Nasturtium microphyllum*), honesty, sweet rocket, and fat-hen. Difficulties in the transmission of all watercress virus isolates to tobacco, using sap extracted from the leaves of infected watercress plants, have since been shown to be due to the presence in watercress leaves of a virus inhibitor.

The relationship between the watercress isolates and other viruses is not yet clear. The symptoms produced on some of the indicator plants tested, suggest that a number of watercress virus isolates resemble cabbage black ringspot virus.

It seems possible that continuous vegetative propagation from infected stocks of watercress is one of the factors responsible for the spread of the virus, but other factors, such as insect transmission, are being investigated. Experiments to test the effect of the virus on the yield of crops are in progress.

## SILVERING DISEASE OF RED BEET (W. G. Keyworth and J. Sheila Howell)

Special attention has been paid during the past year to a study of the causal bacterium and to ways of eliminating it from infected seed. In addition, continued field surveys and experimental plantings have confirmed that the disease is seed-transmitted and that a great deal of secondary infection occurs in the steckling bed from 'seed-infection foci'. The means whereby this spread occurs is still not clear. It is almost certainly partly caused by the splashing of bacteria from infected leaves to healthy ones during rain. The presence of silvering symptoms around holes which have presumably been caused by insect bites suggests that insects may also transmit the disease. However, several tests with flea-beetles and caterpillars, the two most common biting insects on beet leaves, have so far failed to give any proof of this.

*The causal organism.* The growth of the bacterium has been studied on various nutrient media and at various temperatures. The organism is somewhat similar to *Corynebacterium michiganense*, the cause of tomato canker (Grand Rapids disease),

but differs from it and also from other plant pathogenic *Corynebacteria* in certain cultural characters. Moreover, in three experiments it failed to infect tomato plants. These observations indicate that it is probably a new species and when this work is concluded, a description of the bacterium will be published.

*Seed treatment.* Two methods of eliminating the bacterium from infected seed have been tested so far, viz. (a) heat treatment and (b) chemical steeps or dressings. It is not yet possible to say whether heat treatment will be of practical use since it has been found that the tolerance of different seed samples to heating varies quite widely. This work is continuing. The chemical treatment of seed has shown more promise.

After laboratory tests of the toxicity of a range of compounds both to the bacterium and to beet seeds, several compounds were selected for field trials. Seeds from commercial stocks known to be infected with silvering were soaked for 18–24 hours in aqueous solutions containing 0.01 per cent or 0.02 per cent of the compounds. The seeds were then dried for 48 hours and sown in small field plots together with suitable controls. The incidence of silvering in the seedlings was recorded at intervals until they were about three months old. Five such field experiments have been made to date and they have shown that seed treatment with streptomycin may provide an almost complete control of seed-borne infection. The results are still of a preliminary nature, however, and refer only to symptoms in the stecklings. The effects of the treatment on the occurrence of silvering in the mature seed crop will become apparent in the next season.

Trials of seed treatment with streptomycin on a commercial scale have also been made on seven farms and the results will be recorded in the summer of 1956.

Certain other compounds may prove useful as seed dressings against silvering disease and these are to be given further test.

**MINT RUST (W. G. Keyworth and J. Sheila Howell)**

Following preliminary tests in 1954, hot water treatments of enough mint cuttings to plant about half an acre on each of two commercial farms were made in 1955. These tests demonstrated that the 'safety margin' in the treatment is very narrow and that the survival of the treated cuttings is probably affected both by the treatment and by planting conditions. Thus, whereas a treatment at 46°C. (115°F.) for 10 minutes gave good survival in 1954, it caused the death of up to 75 per cent of the cuttings in 1955, especially where dry conditions prevailed. Subsequent treatment of other cuttings at 44°C. (111°F.) gave good survival.

After an initial check the survivors from the 46°C. treatment and the cuttings treated at 44°C. showed good growth and remained substantially free from rust until after the first cutting had been made (end July). Untreated beds nearby showed moderate rust infection. Although the second flush of shoots showed slight infection in August they were still more healthy than the controls, but later on the disease became more widespread. Infection had presumably arisen from spores transmitted from other untreated mint. It appears from these results that the hot water treatment may give a temporary alleviation of the disease, but that this may not be sufficient to warrant the method being used commercially. In any case it is apparent that, unless a whole area could be cleared of rust, the treatment would have to be repeated annually. A further test of the treatment will be made in 1956 and, in addition, other ways of obtaining clean cuttings will be investigated.

Eighteen species and varieties of the genus *Mentha* have been grown at the N.V.R.S. and a preliminary assessment made of rust incidence. Some selections were badly rusted and others showed little or no disease. Two of the latter are strains of *M. spicata* and are apparently closely allied to the commercial varieties in common use. Further trials of these and other varieties are being made to determine whether they continue to show their apparent resistance and whether they could be used as substitutes for some of the more susceptible types.

## STEM AND FRUIT ROT OF OUTDOOR TOMATOES (D. E. Fisher and J. M. Way)

During 1955 there was comparatively little stem rot in outdoor commercial tomato plantations, presumably due to the unusually hot dry summer. Similarly, disease incidence was low in the experimental plots and research has therefore been considerably hampered.

*Seed infection.* Laboratory experiments have shown that both hot water and dry heat are of little value in controlling tomato seed infection by *Didymella* since the thermal death points of the fungus under wet and dry conditions are too close to those of the seed. Chemical steeps are now being tested, such as ethyl mercuric phosphate, phenyl mercuric nitrate, 'Panogen' and 'Aretan', etc.

It has been established that tomato seed can remain infected with *Didymella* for as long as three years.

The tests on seeds have required a reliable method of estimating the total infection of dry seed, i.e., internal and external. Normal culture methods have not been successful owing to the presence of other fungi and bacteria, but satisfactory assessments have been made by placing each seed on the calyx scar of a green tomato fruit and incubating for three weeks. The tomatoes acted as a selective growth-medium and become infected by *Didymella* from the seeds thus enabling the percentage infection to be recorded. Internal infection was assessed by washing the seeds in a disinfectant (3 per cent chloros) for 10 minutes, thus removing external fungi and bacteria, including external *Didymella*, and placing the seeds on an agar medium.

*Sterilisation of canes.* A third series of tests confirmed the results of the two previous seasons' experiments in that either of the two formalin treatments controlled cane infection (3).

In 1955 there was no infection following these treatments or where new canes were used, but 31 per cent of the plants which were supported by untreated bamboo canes were attacked.

*Soil contamination.* Further tests have been made on the carry-over of the disease in the field soil in which infected tomato haulm and fruit were buried in the autumn of 1953 and which carried severely infected tomato crops in 1954. Whereas in 1954, 30 per cent of the plants contracted the disease when planted above the buried infected haulm, there was no evidence of infection in plants put out in the ground in 1955. Similarly, though 54 per cent of the plants were infected in 1954 when planted above buried fruit, there was only 1 per cent of infected plants among those put out in 1955. It is possible that this result may have been caused by the hot dry weather, which appears to have reduced infection in other experiments, and not entirely by the disappearance of the inoculum from the field soil.

*Perithecial stage.* Studies on the perithecia of *Didymella* have shown that the perithecial spores (ascospores) give rise to at least two types of culture. While all the cultures were pathogenic to tomatoes, the experiments indicate that it is necessary for pairs of these cultures to fuse in order to produce further perithecia. The significance of this phenomenon in the development of strains of the fungus is being further studied.

*Tests for resistance.* Several species and varieties of *Lycopersicum* have been re-tested for resistance to *Didymella*. Seedlings were grown in inoculated potting soil and then planted out in the field. Those plants which did not succumb to this mode of infection were re-inoculated directly in the stem, near the end of the season. Certain varieties of *L. hirsutum* have shown some root resistance and slight stem resistance.

## RHUBARB VIRUSES (A. G. Channon)

Work has been concentrated during 1954-55 on one of the two viruses already described (2). This virus is the one associated with ringspot symptoms on the leaves. Although the disease has been found to be common in commercial crops in Warwickshire, Derbyshire and Yorkshire (up to 70 per cent of the plants affected) the symptoms themselves may be very restricted on the individual plants and sometimes are confined to a single basal leaf.

There are several types of ringspots which differ quite markedly in appearance, some being necrotic and others only chlorotic. Associated with these various types of ringspots are light green spots, patches and banding along the principal veins. Coalescence of spots can lead to a more or less generalised mottle. Sap extracts (obtained by the method described by Yale and Vaughan (11)) from rhubarb plants showing these different symptoms, all induced the formation of similar necrotic local lesions when inoculated on to tobacco leaves.

Extractions of sap were made from leaves showing ringspots. The leaves were taken from 10 plants growing in widely separated regions in the Midlands and South of England, and infection of ten-week stocks was carried out. A series of sap transmission tests was made from these stocks, and though the severity of symptom development was variable, all ten isolates infected a number of the hosts known to be susceptible to cabbage ringspot. There is thus some evidence, although not conclusive, that rhubarb ringspot may be related to this disease. Difficulty experienced in transmitting the viruses from rhubarb to other hosts has suggested the possible presence of an inhibitor or inactivator in the sap, and the Chemistry Section is collaborating in the indentification of the substance or substances concerned.

## PARSNIP CANKER (A. G. Channon)

The first object of the work on parsnips has been to eliminate carrot fly from the experiments. This was necessary because not only does the direct damage caused by the larvae render canker assessment difficult, but because it has been shown that sometimes the amount of canker was largely governed by the amount of carrot fly damage (Collingwood and Croxall (1), Stone (6)). If canker was always associated with carrot fly damage the elimination of carrot fly attack might also eliminate canker.

By using very heavy and frequent dressings of dieldrin, carrot fly was almost eliminated from certain plots, only 6–8 per cent of the roots being attacked, usually very slightly. On the untreated plots 43 per cent of the roots were attacked, often severely. In spite of these large differences in carrot fly damage, the amount of canker on the treated and untreated plots was similar (approx. 80 per cent of the roots being affected). The dieldrin treatment thus enabled canker to be studied in the absence of carrot fly attack. It has, in addition, demonstrated that in the winter of 1954-55, at Wellesbourne, the incidence of canker was unrelated to the incidence of carrot fly damage. The type of canker which occurred may thus be said to be a distinct disorder and not secondary to larval injury. It must be noted, however, that this result was obtained after a very wet summer which may have influenced the severity of the disease.

## BOTRYTIS DISEASE OF LETTUCE (J. M. Way)

Two experiments were made on overwintered frame lettuce in the winter and spring of 1954-55. The first was a trial of captan, TCNB, and thiram at various concentrations on May Queen lettuce growing in their final positions in double span Dutch lights. Five applications of the fungicides were given at 21-day intervals from 7th January to 29th March. The trial was designed to give a comparison of the fungicides rather than to provide a practical control method. Records were kept of the incidence of *Botrytis* and an effort was made to differentiate between this and other diseases, mainly damping-off. Wide variations in disease incidence in the control plots prevented definite conclusions from being drawn from this experiment. There were indications, however, that 0.33 per cent thiram spray gave the best disease control. The next best was by TCNB dust at $\frac{1}{4}$ oz. per sq. yd.

The second experiment was a trial of the same fungicides on seedlings overwintered in single span Dutch lights from 4th October to 6th April, when they were planted out in the field. The variety used was Imperial and, although this variety is usually sown in open seedbeds, it grew well and proved quite satisfactory for this trial. Treatments were given at the same 21-day intervals as in the first trial and their effectiveness was assessed on disease incidence in the field, i.e. after the treatments had

ceased. Thiram at 0.33 and 0.66 per cent gave the best results for disease control and numbers of plants cut for market, the differences from the controls being significant at $P=0.05$. Captan spray 0.25 per cent was nearly as good and was also better than the controls. TCNB, although showing promise in the seedbed, failed to prevent subsequent infection in the field. A number of isolations made from plants late in the season indicated that *Botrytis* was the most important disease pathogen present at that stage. These results agree in principle with the findings of Moore and Tew (5), who showed that thiram sprays were better than thiram dusts for the control of strawberry fruit grey mould, and that thiram was more effective than captan or TCNB.

**Acknowledgment**

In many of the experiments, etc., full opportunity has been taken of the facilities put at our disposal by growers, seedsmen and others, and grateful acknowledgment is made of this help.

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# WEED INVESTIGATIONS

By H. A. ROBERTS

## ECOLOGY (Marion E. Smart, H. A. Roberts and J. K. A. Bleasdale)

Soil sampling of the plots in the long-term cultivation and manurial experiments maintained by the Chemistry Section was continued. Samples were taken in the autumn of 1954 in order to determine the numbers and kinds of viable buried weed seeds occurring after the first year of vegetable cropping.

Preliminary field experiments were carried out to investigate the effect of fineness of tilth and degree of seed-bed compaction on the emergence of annual weeds. The effect on the subsequent weed population of harrowing in the first flush of weeds prior to sowing a crop was also investigated, and these experiments will be continued.

Further observations have been made on the viability and dormancy of seeds of annual weeds common in vegetable crops and additional information obtained on the growth of some of these weed species in the field.

## COMPETITION STUDIES (J. K. A. Bleasdale)

During the spring of 1955, experiments were begun to investigate the various factors involved in competition between weeds and vegetable crops. Field investigations included work on crop spacing and time of weeding, whilst both greenhouse and field experiments were started to determine the quantitative relationship between the amount of weed present and the crop yield.

An experiment in pots indicated that mutual shading played only a minor part in competition between carrots and fat-hen (*Chenopodium album*). Other experiments with carrots and chickweed (*Stellaria media*) suggested that the competition effect of weed could be largely described in terms of its final weight at harvest, regardless of its previous history. Thus a small number of weeds present from the early stages of crop growth produced the same effect on crop yield as a larger number of weeds appearing later on. Greenhouse investigations have also shown that the depressant effect of a given amount of weed increased as the crop density increased, thus demonstrating that intensive cropping demands intensive weed control. In experiments where the introduction of weeds was delayed until after the crop had started growth, it was found that competitive effect of the weed was greatly reduced by giving the crop a weed-free start. For example, chickweed sown at the same time as carrots reduced their yield to only 20 per cent of the weed-free control ; when the chickweed was sown two weeks later than the carrots their yield was 80 per cent of the weed-free control. Apart from emphasing the value of weed control in the early stages of growth, when the weeds are most easily killed, it is hoped that this type of information will help in assessing the value of chemical weed control methods involving residual effects.

The time of weed removal has been shown to be important with early carrots grown under Dutch lights. Plots which received a single weeding 25 days after crop emergence gave almost the same yield as the control plots which were kept weed-free throughout the experiment. On plots which were weeded once, earlier than 25 days after crop emergence, the weeds which germinated later had a marked effect on yield. Delaying weeding also reduced the yield, for although there was no subsequent weed growth, the carrots suffered from competition prior to weeding.

## CHEMICAL CONTROL (H. A. Roberts)

Field trials with miscible oil formulations of pentachlorophenol were continued and those on onions are described elsewhere in this Annual Report. Other trials, using the stale seed-bed technique, were carried out on lettuce and red beet. In general, the results of the previous work were confirmed and the performance of the herbicide was satisfactory. There were, however, some instances of damage to the beet crop when application was followed by heavy rain.

Two field trials were carried out to compare the effectiveness of dinoseb and its isopropyl homologue for selective post-emergence weed control in market garden peas. Both compounds were applied at high volume as the ammonium and triethanolamine salts at rates of 0.5, 1 and 2 lb. acid-equivalent per acre. The effects of the two compounds on both weeds and peas were similar, although there were some slight but consistent differences in the response of certain annual weed species. Differences between the ammonium and triethanolamine salts were much greater, the former causing more scorch of the pea foliage. The higher rates of application of the ammonium salts of both compounds also resulted in damage to the stems of the peas whereas this damage was absent in plants sprayed with the triethanolamine salts at the same rates. The degree of weed control obtained with the triethanolamine salts was rather less than that produced by the ammonium salts, but the selectivity was greater. Damage to peas was slight even when, as in a further experiment with the triethanolamine salt of dinoseb, applications were made during the early stages in the growth of the peas.

As part of a programme of experimental work co-ordinated by the A.R.C. Unit of Experimental Agronomy, field trials were put down to explore the practical possibilities for weed control in vegetable crops of certain phenoxybutyric acids (1) (2). These were applied in the form of sodium salts at low volume to ten vegetable crops at two stages of growth and also to mixed stands of annual weeds. Of the four compounds investigated, 4-chlorophenoxybutyric acid proved to be the most generally active, but did not appear to be sufficiently selective, whilst 2, 4, 5-trichlorophenoxybutyric acid was the least active, with comparatively small effects on both crops and weeds. In between were 2-methyl-4-chlorophenoxybutyric acid (MCPB) and 2, 4-dichlorophenoxybutyric acid which killed such weeds as fat-hen (*Chenopodium album*) and pennycress (*Thlaspi arvense*) whilst causing only slight injury to some of the crops. Beet, spinach, lettuce and dwarf French beans were very susceptible to these compounds, but peas, parsnips, carrots and celery were more tolerant. Yield trials were carried out with MCPB on these latter four crops. Further work is required before the value of this group of chemicals for weed control in vegetable crops can be estimated, but it appears from the present trials that MCPB might have some application for the control of susceptible weeds in peas and celery.

Further work with CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) for the control of annual weeds in established beds of asparagus gave encouraging results. When applied in spring, after cultivation but before spear emergence, CMU at the rate of 2 lb. per acre gave excellent control of many species and the beds remained clean throughout the cutting season. No injury to the crop could be detected, in fact the bower on the sprayed plots appeared to be more vigorous than that on the unsprayed control plots, presumably owing to the absence of weed competition. CMU was also tested during two seasons as a pre-emergence treatment for asparagus seed-beds. At rates of 0.5 and 1 lb. per acre, there were no adverse effects on the emergence or growth of the asparagus seedlings and the kill of annual weeds was virtually complete.

Other work included field tests with three residual pre-emergence herbicides, α-chloro-N, N-diallyl acetamide, α-chloro-N, N-diethyl acetamide and 2-chloroallyl diethyldithiocarbamate. Whilst most effective against annual grasses, these compounds have also been reported to control various dicotyledonous weeds (3). The present tests did not suggest that these herbicides are likely to be of much value for controlling the weeds encountered in British vegetable crops. Preliminary trials were also carried out with various chemicals in an attempt to find a suitable method for the control of chickweed (*Stellaria media*) in direct-sown and transplanted spring cabbage.

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(2) WAIN, R. L. (1954). Selective weed control—some new developments at Wye. *Proc. Brit. Weed Cont. Conf.*, 1954, 311-20.

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# A COMPARISON OF PENTACHLOROPHENOL AND SULPHURIC ACID FOR PRE-EMERGENCE WEED CONTROL IN ONIONS

By H. A. ROBERTS

## INTRODUCTION

Spring-sown onions germinate relatively slowly so that frequently many annual weeds emerge before the crop. These can be killed by the application of a suitable contact herbicide shortly before the onions appear. Various chemicals have been tested for this purpose and sulphuric acid has been in commercial use for a number of years. Because of the corrosive properties of acid, however, many growers would welcome a satisfactory alternative, and since 1952, experiments have been in progress to determine whether pentachlorophenol might be suitable. Originally, pentachlorophenol was considered as a fortifying agent for vaporising oil and the results of these experiments have already been discussed (1). In 1954, emulsifiable formulations of pentachlorophenol became available and trials on onions gave encouraging results. It was felt that a comparison with sulphuric acid was desirable and accordingly three trials at different centres were carried out in 1955 in order to compare the efficiency of these two herbicides.

### Methods

The trials were of randomised block design with four to six replicates and a plot size of 1/400 or 1/200 acre. The pentachlorophenol concentrate was diluted with water and all sprays applied at high volume with a knapsack sprayer a few days prior to onion emergence. The acid spray consisted of the standard rate of 13 per cent B.O.V. with the addition of 0.15 per cent of a proprietary wetting agent. Weed kill was assessed by counting survivors of the various species occurring in 25 random one-foot-square quadrats on each plot, after which all plots were inter-row cultivated. The times taken to remove weeds in the row by hand labour were recorded and thereafter the plots were kept free from weeds in order that the crop should not suffer as a result of competition. At harvest the bulbs were lifted, allowed to dry, graded and the numbers and weights recorded. Owing to the dry season the yields were low and the yield figures refer to the totals of all grades. The variety was Ailsa Craig.

## RESULTS

The numbers of surviving annual weeds in each trial together with the times required for weeding the rows are shown in Table I and these data, expressed as mean percentage reductions from the control values, appear in Table II. On all the sprayed plots the populations of weeds and the times taken to hand weed the rows were significantly less than those of the unsprayed control plots. Pentachlorophenol at 4 lb. per acre in all three trials gave results agreeing very closely with those for the standard rate of sulphuric acid, the means (Table II) being almost identical. At the lower rate of application, pentachlorophenol was not so effective, although the difference between the effects of the two rates was not always statistically significant. The general level of weed control was good, but when these trials were sprayed conditions were not favourable for rapid germination so that some weed species tended to appear gradually over a period of weeks rather than in a single flush. Had it not been for this, even better results might have been expected.

At all three places, the higher rate of pentachlorophenol caused some damage to the onions, which took the form of contact injury to the tip of the crook. In one of the trials this was sufficiently severe to reduce the plant population by a significant amount. At the relatively high plant densities employed in these trials, however, this did not result in any adverse effect on the final yield of bulbs (Table II). The injury caused by the lower rate of application and by the sulphuric acid was negligible.

TABLE I

*Numbers of surviving annual weeds and times for weeding rows*

| | Wellesbourne | | Luddington | | Efford | |
|---|---|---|---|---|---|---|
| | Weeds per sq. foot | Weeding time sec./ft. | Weeds per sq. foot | Weeding time sec./ft. | Weeds per sq. foot | Weeding time sec./ft. |
| Pentachlorophenol 2 lb. per acre .. | 14.5 | 8.2 | 6.0 | 11.0 | 19.7 | 9.0 |
| Pentachlorophenol 4 lb. per acre .. | 10.0 | 6.4 | 2.8 | 7.6 | 4.5 | 7.0 |
| Sulphuric acid 13% B.O.V. .. | 9.2 | 6.6 | 2.3 | 6.8 | 7.0 | 7.6 |
| Control .. .. | 46.1 | 17.4 | 15.1 | 17.3 | 32.8 | 11.4 |
| s.e. of difference between two treatment means .. | ±2.9 | ±1.4 | ±0.9 | ±1.8 | ±2.8 | ±0.8 |

TABLE II

*Summary of weed kills, weeding times and yields of onions.*

| | Means of three trials | | Yield of dry bulbs Tons per acre | | |
|---|---|---|---|---|---|
| | Percent. kill of weeds | Percent. reduction in weeding time | Wellesbourne | Luddington | Efford |
| Pentachlorophenol 2 lb. per acre .. | 57.2 | 38.8 | 8.3 | 10.2 | 16.2 |
| Pentachlorophenol 4 lb. per acre .. | 81.6 | 54.5 | 8.7 | 10.6 | 15.6 |
| Sulphuric acid 13% B.O.V. .. | 80.3 | 54.5 | 8.6 | 12.3 | 17.4 |
| Control .. .. | — | — | 7.6 | 11.1 | 15.7 |
| s.e. of difference between two treatment means .. | — | — | ±0.4 | ±1.2 | ±1.0 |

## DISCUSSION

It has been previously emphasised that the contact pre-emergence method of weed control is applicable only when the majority of weeds emerge before the crop (1). In the present trials most of the weed species did so, but a few, for example *Spergula arvensis* at Efford and *Polygonum aviculare* at Wellesbourne, had only emerged to the extent of 60 per cent at the time of spraying. Apart from these instances, weed control was uniformly good in all three trials. The time required for hand weeding the rows was proportional to the surviving weed population for any one place, but the decrease in weeding time resulting from a given reduction in the number of weeds varied between places. This was probably due, at least in part, to differences in the method of carrying out the work. The relationship between these factors will be discussed at length in a later paper. At two places a second hand weeding was done later in the season. This was timed and there were again considerable differences between the sprayed and unsprayed plots in the amounts of labour needed, although, as might be expected, they were not so great as those shown in Table I.

It is concluded that pentachlorophenol in the miscible oil type of formulation used in these trials is a satisfactory alternative to sulphuric acid for pre-emergence use in spring-sown onions. In view of the relatively small differences in weeding time between the two rates of application, it would seem that perhaps an intermediate rate of about 3 lb. per acre might be most satisfactory in practice. Provided that there is a good initial germination of onions, such a rate would not, on the evidence of these trials, be liable to result in adverse effects on yield.

**Acknowledgment**

Thanks are due to the Directors and staffs of the N.A.A.S. E.H.S. at Efford and Luddington for their co-operation.

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# STATISTICS REPORT

By J. A. NELDER

The Statistics Section has continued to assist other sections of the Station in the statistical aspects of their work. The chief topics on which advice has been sought are the fitting of response curves, the estimation of sample sizes for future work from preliminary data, and the analysis of complex designs.

## FIELD EXPERIMENTAL TECHNIQUE (J. A. Nelder and D. Cooke)

The usefulness of uniformity trials as a guide to the planning of experiments depends on the discovery of an empirical rule relating the variability of yield from a plot to the size and shape of that plot. Fairfield Smith (1) has suggested an empirical law for expressing this relationship ; and Quenouille (2) and others have suggested considering the plots of an experiment as possessing a certain correlation pattern, with the correlation between any two plots falling off as the distance between them increases. The relation between these two approaches has never been clear, and when we found that Fairfield Smith's law did not give a satisfactory fit to uniformity data on brassica crops, it was decided to set up some artificial samples based on plausible correlation patterns, to help in elucidating the problem. The problem of constructing such samples has been partly solved, in theory, by Hammersley and Nelder (3), but the practical application of the method has encountered some difficulties, which are being further studied.

Experiments aimed at improving the accuracy of field trials with vegetables have been continued. The accurate measurement of the variance of individual treatments demands that a large number of plots of each treatment be used, and several years' results will be necessary before satisfactory conclusions can be drawn. The experiments on lettuce and peas mentioned in the Fifth Annual Report for 1954 have been repeated, and two new experiments have been carried out on summer cauliflower and carrots. There is, unavoidably, considerable variation in the size of cauliflower plants at the planting-out stage, and the effect of size at planting-out on subsequent development was followed up, with the idea that unwanted variation in the crop might be reduced by allocating to each plot the correct proportion of each size-group at planting-out. The estimated increase in accuracy in the measurement of yield was disappointingly small, but improved accuracy was obtained in the measurement of mean date of maturity. The effect of hand thinning on the evenness of carrots was investigated, and the first results indicate a definite improvement from hand thinning.

## POLYGENIC VARIATION (J. A. Nelder)

Parent, $F_1$, $F_2$ and $F_3$ populations from four varieties of French bean have been grown to provide material for the study of polygenic variation, data being collected on flowering time and seed size. A subsidiary experiment was carried out to provide information on the amount of genetic variation remaining in the four parent varieties. In the parent strains, marked interaction of flowering time with environment was noted in a summer which provided a wide range of temperatures in the period May-September.

A small sample of seed was received in 1955 of an American variety of French bean, Ranger, said to be specially suited to mechanical harvesting. A small trial of this variety against Refugee, the standard English canning variety, was carried out and observations were made on the duration of harvest and yield. The Fruit and Vegetable Canning and Quick Freezing Research Association at Chipping Campden kindly co-operated in carrying out canning and quick-freeze tests on samples from these two varieties, and a report is being prepared.

## WORK FOR OTHER BODIES

Members of the Section have continued to serve on several Working Parties of the Agricultural Improvement Council's Experimental Horticulture Committee, J. A. Nelder on the Glasshouse and the Protected Cropping Working Parties, and D. Cooke on the Bulbs and Flowers Working Parties. In collaboration with N. Moss of Luddington E.H.S., J. A. Nelder prepared a paper for publication on the results of some lettuce spacing experiments in glasshouses carried out at the Luddington E.H.S. In collaboration with Mr. C. P. Quarrell, D. Coòke is preparing a report on some experiments carried out over two years by several of the Experimental Horticulture Stations under the sponsorship of the Flowers Working Party, on the propagation of chrysanthemum cuttings.

The section has been concerned with the design and analysis of 30 experiments for outside bodies during the year, involving about 1,280 plots. Most of these experiments were carried out at the N.A.A.S. E.H.S. at Efford, Fairfield, Luddington, Rosewarne and Stockbridge House ; others were done at the N.A.A.S. Experimental Husbandry Farm at Kirton and by the Experimental Horticulture Committees of various provinces of the N.A.A.S.

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(3) HAMMERSLEY, J. M. and NELDER, J. A. (1955). Sampling from an isotropic Gaussian process. *Proc. Camb. Phil. Soc.*, **51**, 652-62.

# THE WEATHER DURING 1955

## RECORDS OF THE N.V.R.S. CROP WEATHER STATION

By JOSEPHINE I. E. RUBIO, E. J. WINTER and G. STANHILL

Owing to building development, it became necessary to move the weather station to a new site near the south west boundary of Sheep Pens field in January 1955. The equipment was supplemented by an evaporation tank of standard dimensions (1) and a number of weighable monolith soil cores having grass-covered surfaces flush with surrounding grass ; these were for measuring the evaporation and transpiration of water.

During the early spring of 1955 the wet, cold weather frequently hindered agricultural operations ; April was unusually dry but rainfall in May was almost double the five-year average. During a storm on 6th May, rain fell for a short time at the rate of over one inch per hour. A hailstorm on the same day, caused severe damage to seedlings and in places the drifted hail lay nine inches deep.

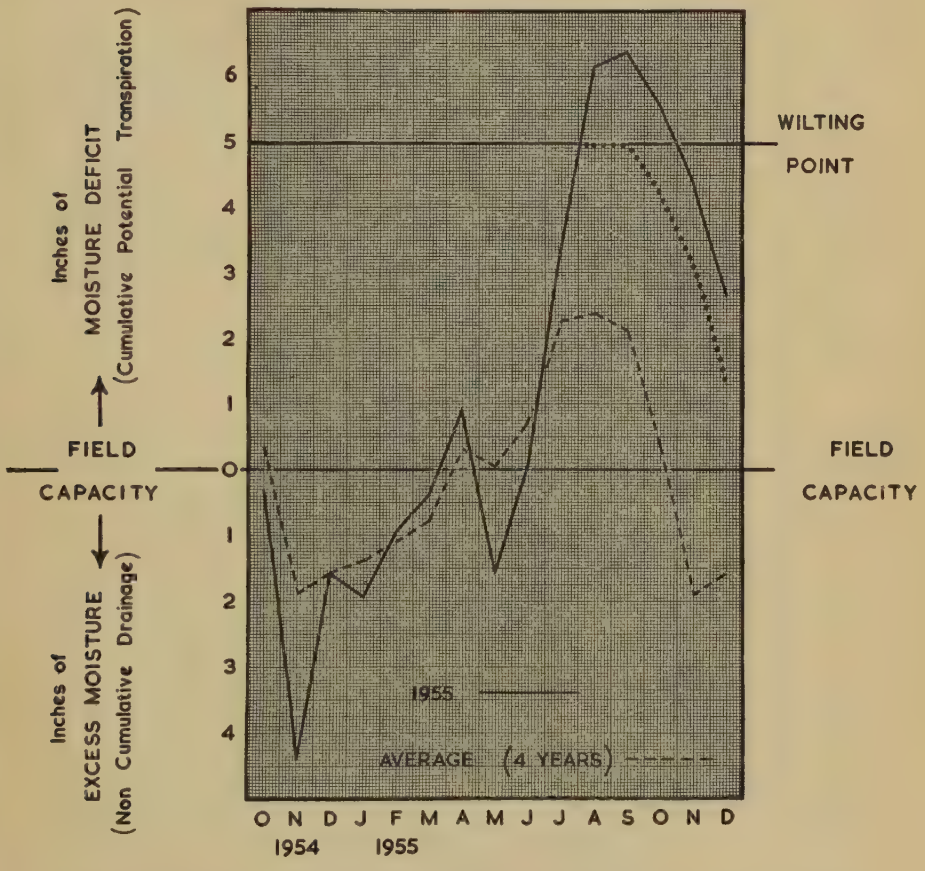



Fig. 1. Theoretical moisture status of a soil at Wellesbourne completely covered with a green crop. The dotted line shows estimated values for soil moisture deficit on the assumption that there was no further loss of water after the top 3 feet of soil had reached wilting point.

During May, over 1½ inches of drainage occurred and the moisture content of the soil remained near field capacity until early July. In most years the soil moisture content falls below field capacity during early April. From July 1955 onwards, rainfall was extremely light and evaporation was high so that by mid-August the potential soil moisture deficit under a green crop was 6.15 inches. The actual deficit, however, was less than this because in Sheep Pens field the total available water in the top 3 feet of soil was only 5 inches.

Absolute drought was recorded on the 18 days following 7th April, and again during the 14 days following 18th July ; a negligible amount of rain fell between 4th and 16th July and between 11th and 23rd November. By the end of the year the potential deficit was still 2.63 inches. Field drains had not begun to flow by 31st December, and so it seems probable that an actual soil moisture deficit continued into 1956.

Fig. 1 shows the theoretical moisture status of Wellesbourne soil during 1955.

The total rainfall during 1955 was 19.01 inches which was nearly 6 inches less than the average for the last few years and 10 inches less than in 1954.

The weather was excellent for haymaking and for the cereal harvest, but lack of rain seriously reduced the yield of crops such as potatoes and carrots.

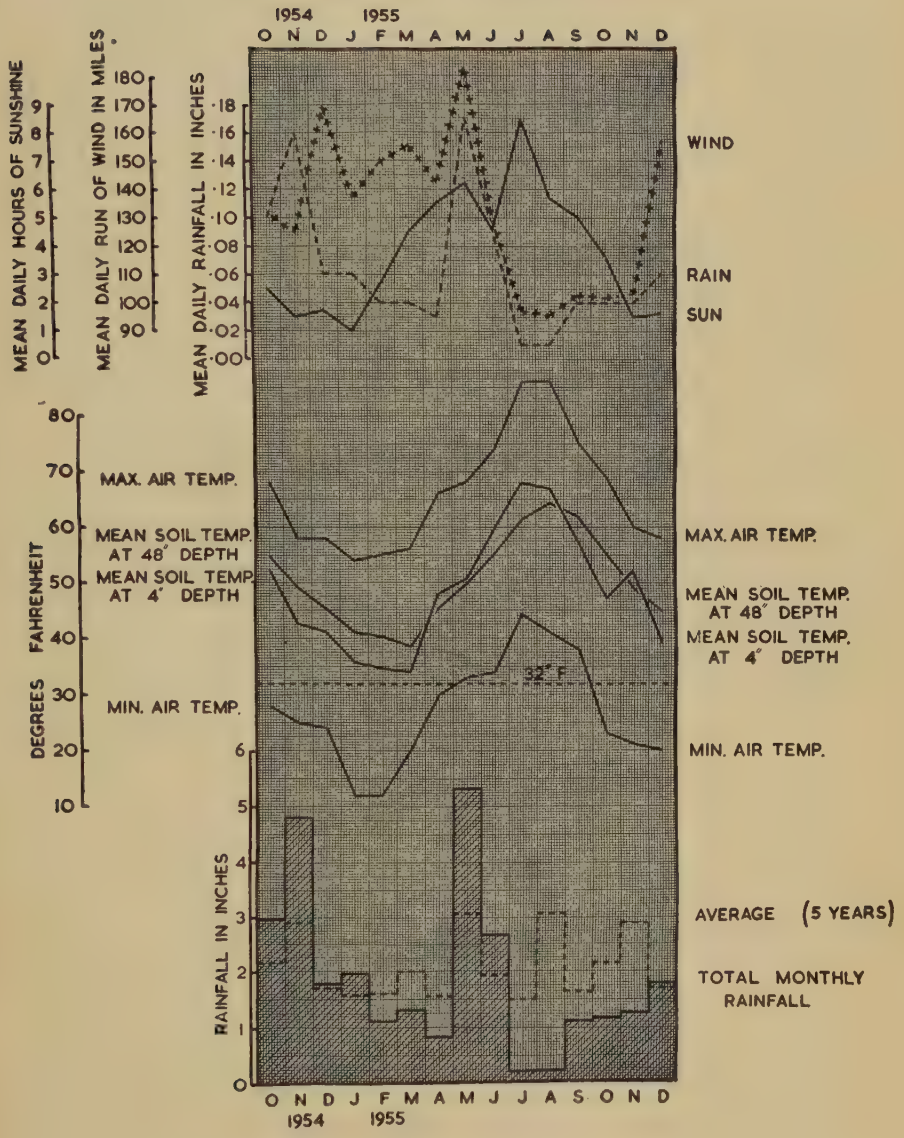
The weather records are summarised in Table 1 and Fig. 2.

TABLE I

*Summary of various weather features during* 1955

| | | | *5-year average |
|---|---|---|---|
| Sunshine : | sunniest month .. | July (daily average—8.4 hours) | 6.1 hours. |
| | dullest month .. | January (daily average—1.0 hour) | 1.5 hours. |
| | most in a day .. | 14.5 hours on 30th May (89% of the possible) | |
| Rainfall : | wettest month .. | May (5.32 inches) | 3.07 inches. |
| | driest month .. | July (0.21 inches) | 1.50 inches. |
| | most in a day .. | 1.74 inches on 6th May. | |
| | total during 1955 .. | 19.01 inches | 24.78 inches. |
| Wind : | windiest month .. | May (daily average run—183 miles) | 119 miles. |
| | calmest month .. | June (daily average run—94 miles) | 97 miles. |
| | windiest day .. | 4th May (345.7 miles) | |
| | calmest day .. | 31st October (3.03 miles) | |
| | daily average run of wind during 1955—129 miles | | 119 miles. |
| Air temperature : | warmest month | 65°F. mean temperature in August | 64°F. |
| | coldest month .. | 34°F. mean temperature in February | 37°F. |
| | highest maximum .. | 86°F. on 17th July and 23rd August. | |
| During winter 1954-55 : | | | |
| | lowest minimum .. | 12°F. on 20th January and 28th February, i.e., 19 degrees of frost. | |
| | first air frost .. | 28°F. on 26th October, 1954. | |
| | last air frost .. | 30°F. on 25th April, 1955. | |
| | number of nights with air frost—76 | | 74 |
| | number of nights with ground frost—98 | | 106 |

* The averages refer to the corresponding month or period during the previous five years. Thus, in the first entry in the Table, the average daily number of hours of sunshine for July during the past five years was 6.1, but July was not necessarily the sunniest month in every year.


1954 1955
O N D J F M A M J J A S O N D
MEAN DAILY HOURS OF SUNSHINE
MEAN DAILY RUN OF WIND IN MILES
MEAN DAILY RAINFALL IN INCHES
WIND
RAIN
SUN
DEGREES FAHRENHEIT
MAX. AIR TEMP.
MEAN SOIL TEMP. AT 48" DEPTH
MEAN SOIL TEMP. AT 4" DEPTH
MIN. AIR TEMP.
32° F
RAINFALL IN INCHES
AVERAGE (5 YEARS)
TOTAL MONTHLY RAINFALL
O N D J F M A M J J A S O N D
1954 1955

## REFERENCE

(1) LAPWORTH, C., GLASSPOOLE, J. and LLOYD, D. (1948). Report on standard methods of measurement of evaporation. J. Instn Wat. Engrs.

# LIBRARY REPORT

By CHRISTINE M. ROWE and H. A. ROBERTS

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The Library has continued to operate on the lines described previously and a satisfactory year can be reported. Holdings of the main categories of material on 30th September, 1955, are as follows :—

| | |
|---|---|
| Current periodicals .. .. .. .. | 122 |
| Bound periodical volumes .. .. .. | 253 |
| Current annual reports .. .. .. .. | 89 |
| Books and reference works .. .. .. | 265 |
| Separates .. .. .. .. .. .. | 1,814 |

During the year, thirteen periodicals were taken for the first time and several runs of back numbers were obtained to meet the needs of the Chemistry Section in particular. A batch of more than a hundred volumes was despatched for binding. Some agreements were negotiated whereby items will be obtained in exchange for the N.V.R.S. Annual Report. About thirty books and reference works were added to the Library and more than three hundred separates were received.

Internal loans during the year totalled 1,727 and 137 items were obtained on loan from other libraries at the request of members of staff.

# PUBLICATION RECORD

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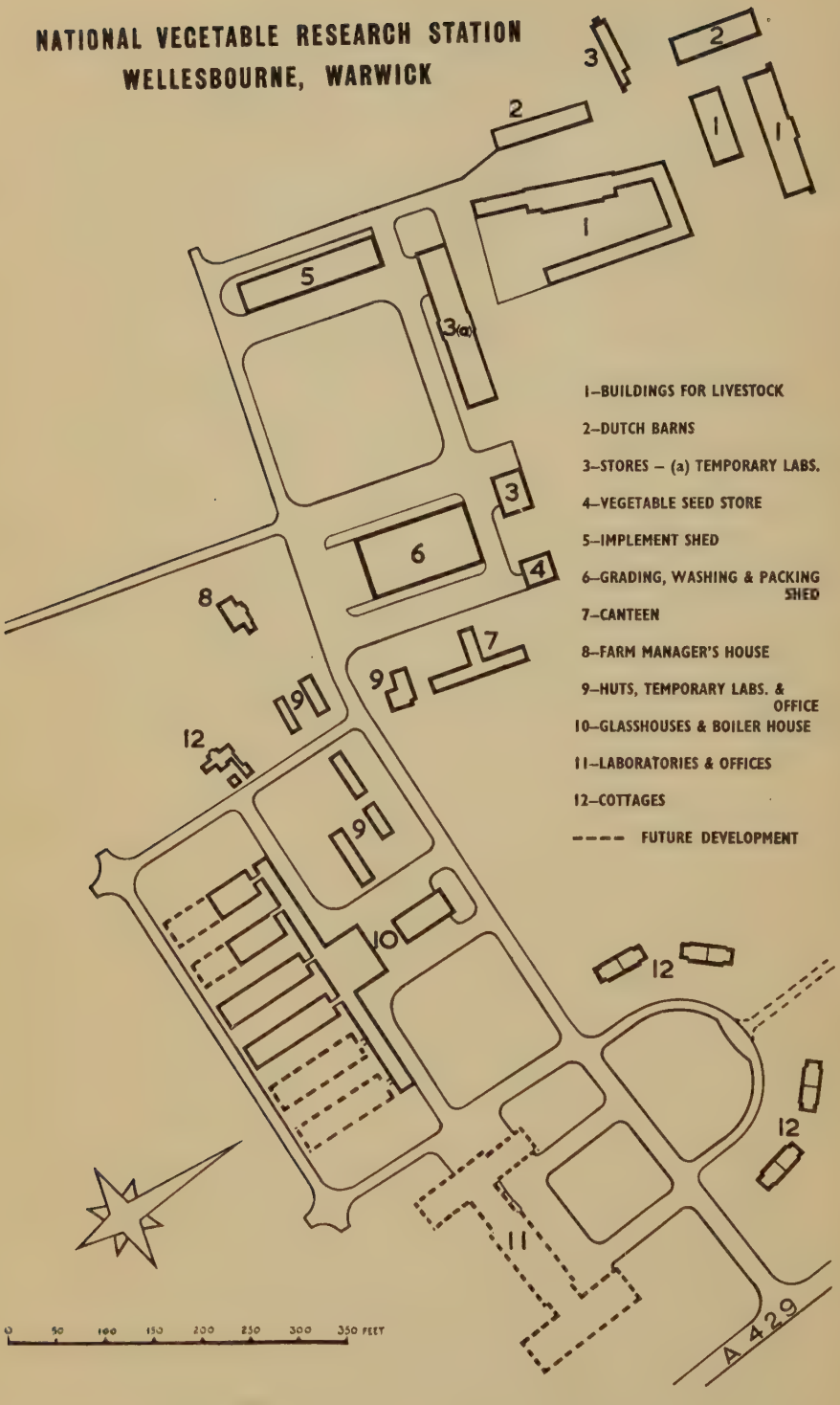
# NATIONAL VEGETABLE RESEARCH STATION
## WELLESBOURNE, WARWICK



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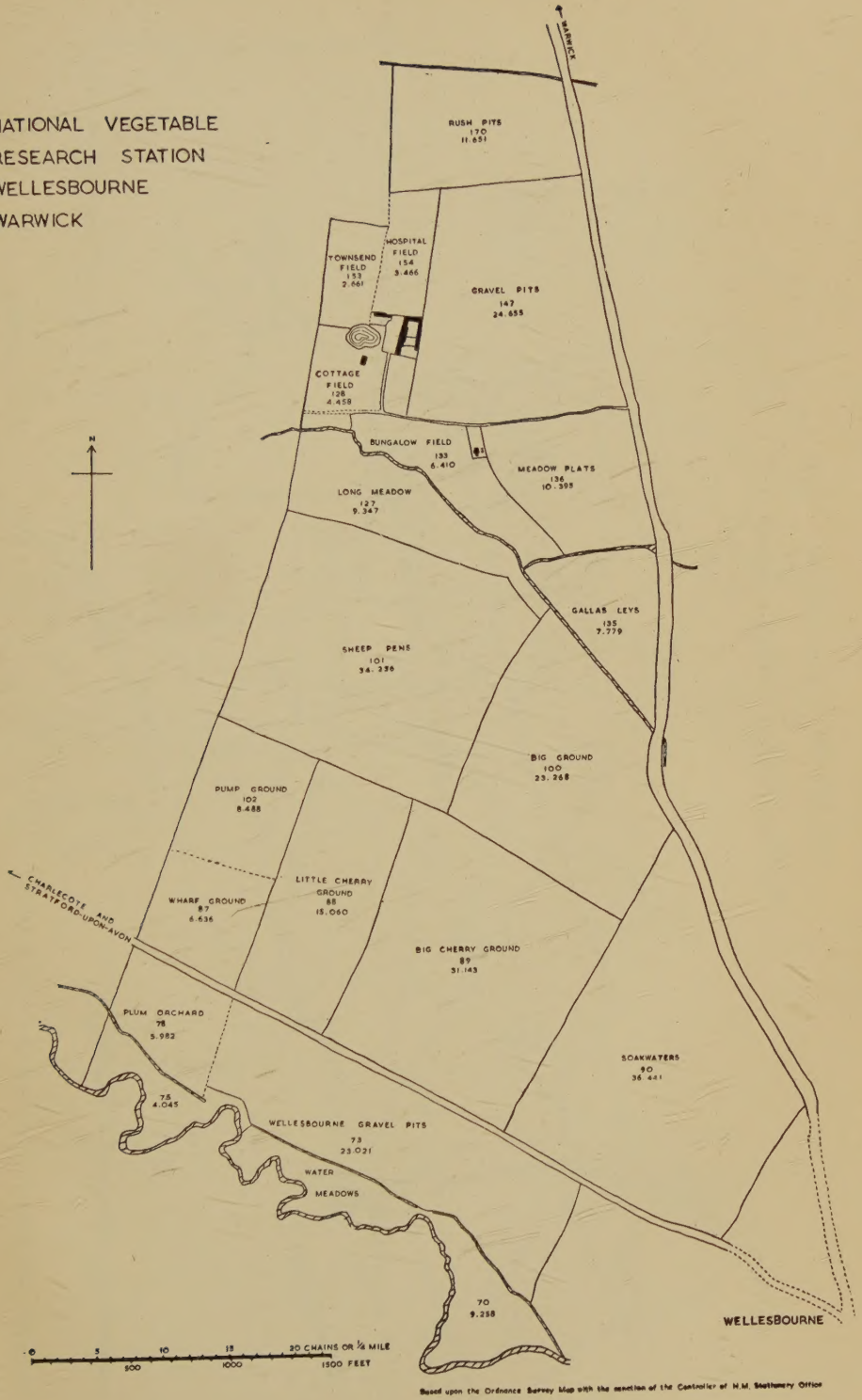
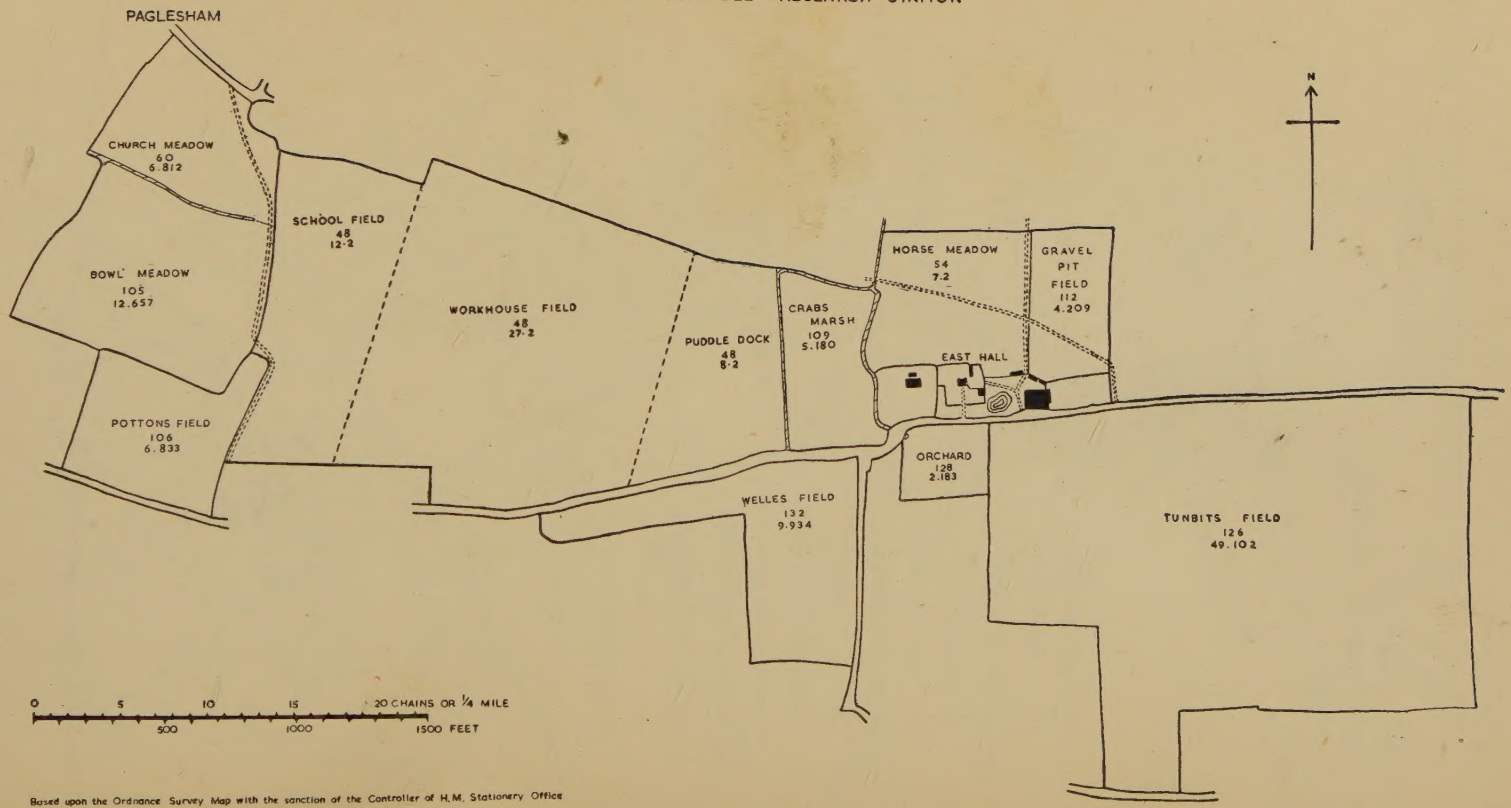



Based upon the Ordnance Survey Map with the sanction of the Controller of H.M. Stationery Office

# PAGLESHAM SUB-STATION

OF THE

## NATIONAL VEGETABLE RESEARCH STATION

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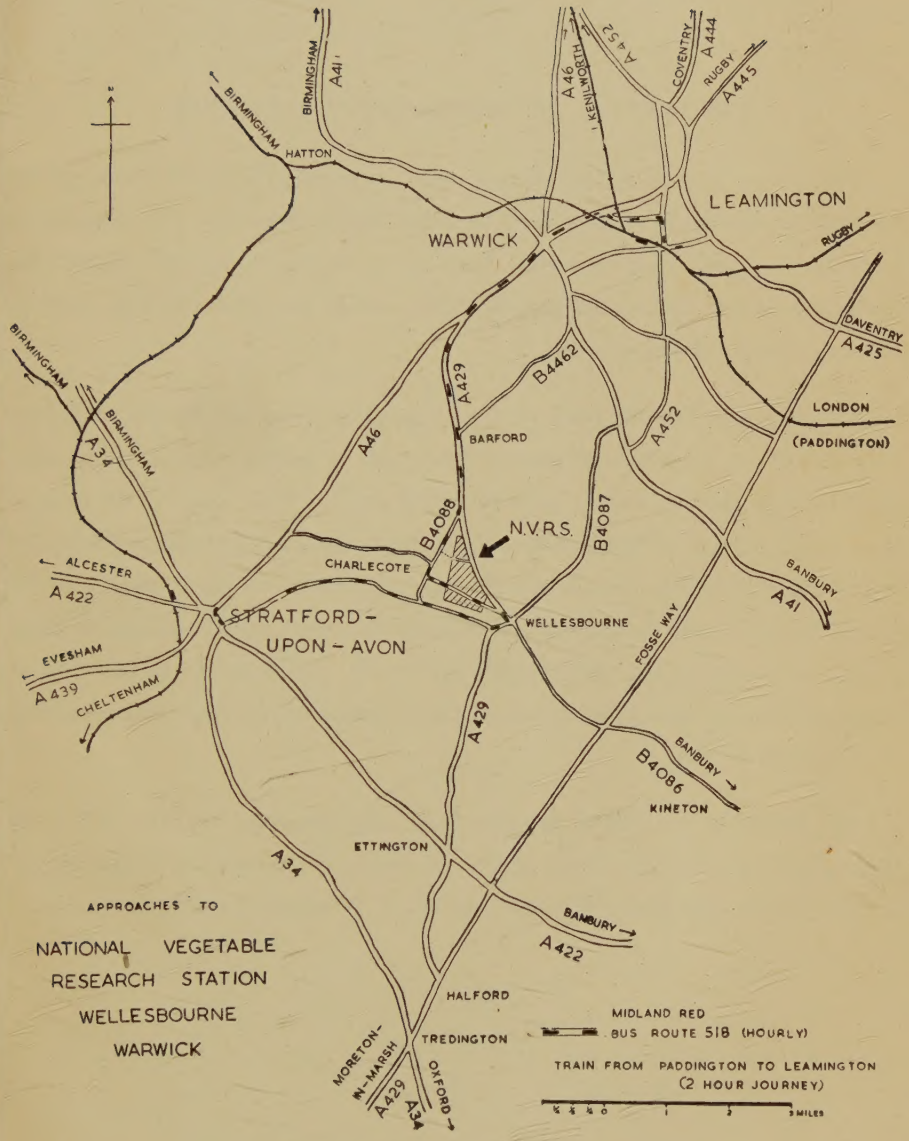
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KENILWORTH
A452
COVENTRY
A444
RUGBY
A445
LEAMINGTON
WARWICK
RUGBY
DAVENTRY
A425
LONDON
(PADDINGTON)
BIRMINGHAM
A34
BIRMINGHAM
A46
A429
B4462
BARFORD
A452
B4088
N.V.R.S.
B4087
ALCESTER
A422
CHARLECOTE
BANBURY
A41
STRATFORD-
UPON-AVON
WELLESBOURNE
FOSSE WAY
EVESHAM
A439
CHELTENHAM
A429
BANBURY
B4086
KINETON
ETTINGTON
A34
BANBURY
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HALFORD
TREDINGTON
MORETON-
IN-MARSH
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APPROACHES TO
NATIONAL VEGETABLE
RESEARCH STATION
WELLESBOURNE
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TRAIN FROM PADDINGTON TO LEAMINGTON
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## THE JOURNAL OF HORTICULTURAL SCIENCE

*The Journal of Horticultural Science*, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home or abroad. Papers for publication and all communications should be sent to the Editors at East Malling Research Station, Maidstone, Kent.

Recent papers describe work on fruit, vegetables, hops and flowers, including cultural studies ; the effects of mineral deficiencies in various crops such as apple, broccoli, cacao, potato, tomato, strawberry and bulbs ; fruit storage ; the biology and control of pests of fruit and their predators ; the control of fungous diseases ; virus diseases ; genetical studies of fruits and vegetables ; soil sterilisation. In the current Volume 31, there begins a new series on the effects of light quality on plant growth and development ; this volume also includes papers on the germination of vegetable seeds, the spacing of lettuces in glasshouses, and two important papers on virus diseases of fruits.

The publishers are Messrs. Headley Bros., 109 Kingsway, London, W.C.2., to whom intending subscribers should apply. The subscription rates are 50 shillings per volume (rate for Canada and the U.S.A. $7.00), or 15 shillings for a single number.